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instruments

SI3535D, F & G Scorpio Data Logger

USER GUIDE

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DECLARATION OF CONFORMITY

The directives covered by this declaration

73/23/EEC	Low Voltage Equipment Directive, amended by 93/68/EEC
89/336/EEC	Electromagnetic Compatibility Directive, amended by 92/31/EEC & 93/68/EEC

Product(s)

SI3535 Scorpio Data Logger

provided that the product consists only of a 3535D, 3535F or 3535G mainframe (or a 3535E Slave expansion unit), fitted with any combination of the following modules: 35301A, 35301B, 35351C, 35351D, 35301E, 35302A, 35302B, 35302C, 35304A, 35304B, 35303A, 35303B, 35353C.

Basis on which conformity is being declared

The product(s) identified above comply with the requirements of the EU directives by meeting the following standards:

BS EN50081-1:1992	Electromagnetic Compatibility - Generic Emission Standard Part 1: Residential, commercial and light industry.
BS EN50082-1:1992	Electromagnetic Compatibility - Generic Immunity Standard Part 1: Residential, commercial and light industry.
EN61010-1:1993	Safety requirements for electrical equipment for measurement, control and laboratory use.

Accordingly the CE mark has been applied to this product.

Signed Derek Page

For and on behalf of Solartron, a division of Solartron Group Limited

Authority: Engineering Manager.

Date: **December 1995**

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SI3535
Scorpio Data Logger

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Solartron pursue a policy of continuous development and product improvement.
The specification in this document may therefore be changed without notice.

SI3535 User Guide Contents

Chapter

1 Introduction

Introduces the many powerful facilities of the SI 3535 Data Logger.

2 Measurement Techniques

Describes the theory behind the measurement ability of the SI 3535 and gives some practical considerations for achieving optimum accuracy in your results.

3 Installation *[Essential reading]*

Gives detailed instructions on how to install an SI 3535 in your particular system, and how to upgrade from Orion 3530 or 3531 Data Loggers.

4 Using the SI 3535

Tells you how to use the SI 3535 in defining the system tasks.

5 Logger Facilities

Tells you how to control the SI 3535, from the instrument front panel.

6 Conversions and Alarms

Describes how the measured data may be converted to a more understandable and useful form, and also how the data may be "reduced" by comparing it with pre-defined alarm limits and outputting only the significant results.

7 Output Formats

Describes the various forms in which data may be output from the logger.

8 Disk Drive

Describes how to use the integral disk drive in the SI 3535D and G Loggers.

9 Data Acquisition Modules

Gives a brief technical description of each SI 3535 module, with particular emphasis on the types of signal measured, the input (or output) connections to be made, and the measurement timing.

10 Transient Capture

Describes how to capture transients, with a logger that is equipped with the SI 35351F Transient Capture Module.

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App. B Typical Throughputs

App. C Thermocouple Measurement Accuracy

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GENERAL SAFETY PRECAUTIONS

The equipment described in this manual has been designed in accordance with IEC publication 348 (Class 1) Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. To avoid injury to an operator or service technician the safety precautions given below, and throughout the manual, must be strictly adhered to, whenever the equipment is operated, serviced or repaired. For specific safety details, please refer to the relevant sections within the manual.

The equipment is designed solely for electronic measurement and should be used for no other purpose. Solartron Instruments accept no responsibility for accidents or damage resulting from any failure to comply with these precautions.

GROUNDING
To minimize the hazard of electrical shock it is essential that the equipment is connected to a protective ground whenever the power supply, measurement or control circuits are connected, even if the equipment is switched off. The protective ground for ac and dc supplies is connected separately.

AC GROUND is connected via the ac supply cord. The cord must be plugged into an ac line outlet with a protective ground contact. When an extension lead is used, this must also contain a ground conductor. Always connect the ac supply cord to the supply outlet before connecting the control and signal cables; and, conversely, always disconnect control and signal cables before disconnecting the ac supply cord. The ac ground connection must have a continuous current rating of 6A.

DC GROUND is connected via a ground stud on the equipment power supply unit (PSU). The dc ground connection must have a continuous current rating of 35A.

Where both protective grounds are used it must be ensured that these grounds are, and will remain, at the same potential.

AC SUPPLY VOLTAGE
Never operate the equipment from a line voltage or frequency in excess of that specified. Otherwise, the insulation of internal components may break down and cause excessive leakage currents.

FUSES
Before switching on the equipment check that the fuses accessible from the exterior of the equipment are of the correct rating. The rating of the ac line fuse must be in accordance with the voltage of the ac supply.

Should any fuse continually blow, do not insert a fuse of a higher rating. Switch the equipment off, clearly label it "unserviceable" and inform a service technician.

EXPLOSIVE ATMOSPHERES
NEVER OPERATE the equipment, or any sensors connected to the equipment, in a potentially explosive atmosphere. It is NOT intrinsically safe and could possibly cause an explosion.

Continued overleaf.

SAFETY PRECAUTIONS (continued from previous page)

SAFETY SYMBOLS

For the guidance and protection of the user, the following safety symbols appear on the equipment:

SYMBOL	MEANING
	Refer to operating manual for detailed instructions of use.
	Hazardous voltages.
	Protective conductor terminal. This must be connected to ground before operating the equipment.

NOTES, CAUTIONS AND WARNINGS

For the guidance and protection of the user, Notes, Cautions and Warnings appear throughout the manual. The significance of these is as follows:

NOTES	highlight important information for the reader's special attention.
CAUTIONS	guide the reader in avoiding damage to the equipment.
WARNINGS	guide the reader in avoiding a hazard that could cause injury or death.

AVOID UNSAFE EQUIPMENT

The equipment may be unsafe if any of the following statements apply:

- Equipment shows visible damage.
- Equipment has failed to perform an intended operation.
- Equipment has been subjected to prolonged storage under unfavorable conditions.
- Equipment has been subjected to severe physical stress.

If in any doubt as to the serviceability of the equipment, don't use it. Get it properly checked out by a qualified service technician.

LIVE CONDUCTORS

When the equipment is connected to its measurement inputs or supply, the opening of covers or removal of parts could expose live conductors. The equipment must be disconnected from all power and signal sources before it is opened for any adjustment, replacement, maintenance or repair. Adjustments, maintenance or repair, must be done only by qualified personnel, who should refer to the Maintenance Manual.

EQUIPMENT MODIFICATION

To avoid introducing safety hazards, never install non-standard parts in the equipment, or make any unauthorized modification. To maintain safety, always return the equipment to Solartron Instruments for service and repair.

Chapter 1
Introduction

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1 THE SI 3535 MEASUREMENT HARDWARE

The SI 3535 loggers provide versatile and flexible data acquisition and data processing.

A wide range of measurements is possible, e.g. strain and temperature, which can be derived from a combination of digital and analog inputs. Output responses (digital and analog) are also available.

The various forms in which the SI 3535 is made available are described in Section 1.1, whilst the main features of the SI 3535 are described in Section 1.2.

1.1 SI 3535 VARIANTS

SI 3535 is available in the following variants:

(a) SI 3535D Data Logger, which has an integral front panel display (Fig 1.1), a control keypad, keyswitch, printer and a 3.5 in. floppy-disk drive.

(b) SI 3535F and G Measurement Front Ends, which are each intended for use with a computer, and are not fitted with front panel displays. (Both models can, however, be used with a VT 220 terminal acting as a front panel emulator.) Both versions have essentially the same measurement and processing capabilities as SI 3535D.

- SI 3535F has a front panel that contains only a keyswitch, RS232 connector and three LED indicators.
- SI 3535G is similar to SI 3535F but with the addition of a 3.5 in. floppy-disk drive.

(c) SI 3535E which is intended as a slave unit for use with any of the above, to provide additional measurement channels.

Up to eight SI 3535 D, F or G units can be remotely controlled by an SI 3470 Scorpio PC-Based Data Acquisition Controller. Under these conditions the SI 3535 performs the role of a measurement front end (MFE) and the Scorpio Data Acquition Controller is free to handle the storage and presentation of the overall results. (See the separate SI 3470 Operating Manual for instruction on the use of the PC-based software.

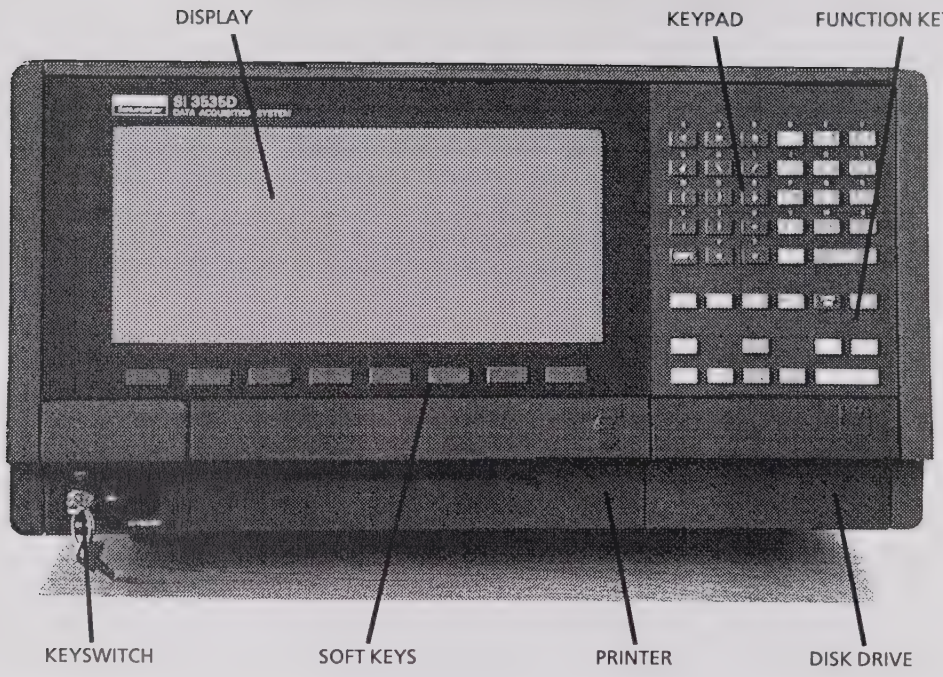

Fig 1.1 *Front panel, SI 3535D Scorpio Data Logger.*

1.2 MAIN FEATURES

The SI 3535 loggers provide the following features:

(a) A configuration of input/output modules that can be user-selected to suit specific measurement applications.

(b) Measurement of analog signal inputs with a high degree of accuracy and linearity, using an analog-to-digital converter.

(c) Transient capture option. A logger can contain up to four transient capture modules, each module able to capture up to four transient signals simultaneously.

(d) Measurement from sources providing digital data, as either single bits or grouped bits.

(e) Generation of digital outputs to provide alarm/stimuli information.

(f) Generation of analog outputs to control external recording devices.

(g) Set-up and control, either locally from a front panel (SI 3535D) or via a remote computer (all SI 3535 variants).

(h) Floppy-disk storage and replay of logged data (SI 3535D and G).

(i) Built-in thermal printer provides an instant record of logged data or setting-up conditions (SI 3535D only).

(j) Operation from an ac line supply, or by dc from an external battery, with automatic switchover in the event of ac failure.

2 DATA LOGGING FUNCTIONS

The data logging functions available with SI 3535 loggers include scanning, linearization, user-defined processing and alarm checking.

Setting up a data logger involves several stages:

(a) Connecting transducers (measuring devices) to the logger input channels.

(b) Defining channels: specifying any transducer energisation and linearization required, alarm conditions, and any text to be output with channel reading.

(c) Defining tasks: specifying which channels are to be included in a task, what data is to be output, and which output devices are to be used.

2.1 TASKS

Tasks are used to define data-logging routines, which involve a schedule of measurement channels.

The tasks within a SI 3535 logger can be independent or inter-related. Typically, one task can scan regularly, checking for specific events and can trigger a second task to scan more rapidly when such an event occurs. Complex routines can be built up to run automatically.

2.1.1 Multi-Tasking

A maximum of eight prioritized tasks can be assigned to scan different sets of channels at varying intervals, and with varying degrees of resolution. Each task (1 to 8) has its own processing program, the higher numbers having priority over lower numbers. The tasks can be independent separate logging routines, or they can be made interdependent by means of suitable cross-triggering.

Tasks can have an associated end-of-scan processing program to carry out a mathematical assessment of the task results.

In a typical application one task can be set up to scan a number of channels periodically, looking for critical values but not recording the results. When such a value is found, a second task can be triggered to scan more rapidly and capture, record and analyse the activity. Refer to Chapter 5 section 1.1 for diagram of task data flow.

2.2 SYSTEM INPUTS

Various types of inputs, both analog and digital, can be connected to the SI 3535 through a range of module options.

Analog inputs include the following:

- Ac and dc voltages and currents.
- Electrical resistance.
- Thermocouples and platinum resistance thermometers (PRT).
- Strain gage measurements in various bridge configurations.

Digital inputs include the following:

- Status signals (e.g. external switch positions).
- Event detection and monitoring.
- Timing and counting of events.
- Frequency totalizing, period and interval measurement.

Before using the SI 3535 for logging and measurement, the logging schedule should be outlined to decide the measurement objectives. Having identified the types of parameter to be measured, suitable input modules can be selected from the SI 3535 range.

2.2.1 Analog Inputs

Using analog selectors, several types of analog measurement are possible including those of electrical parameters, temperature, and strain. Certain types of transducer, e.g. strain gages, require energization and this is provided by the SI 3535 energization module. The energization voltage or current from this module is switched automatically by the input selectors to each transducer in turn, just before measurement of its associated input.

Similarly, each analog input is switched to the analog measuring circuit of the SI 3535 (see Section 2.4) by one of the following input selector modules:

- Reed Relay Selector.
- Solid-State Selector.
- High Voltage Solid-State Selector.

2.2.2 Digital Inputs

Three types of digital inputs are recognised by the SI 3535: status inputs, event inputs and pulse streams.

Status inputs are logic levels (High and Low; "1" and "0") representative of the status of an external system. These inputs are scanned periodically. Single inputs are normally derived from switches and sensors, whereas grouped inputs (eg BCD) are obtained from other instruments or external measurement modules.

Events are high→low or low→high transitions representative of a change in status: each one is treated as an "alarm" and can be used to interrupt a logging "task". Events are monitored through a user-defined time "window".

Pulse streams are produced by devices such as flow meters and shaft speed indicators. The SI 3535 is able measure both the frequency and the period of such signals.

2.3 SYSTEM OUTPUTS

The SI 3535 can provide both analog and digital outputs.

Analog outputs can be assigned to an input channel by the Channel Definition, or may be controlled by the processing at the end of a scan task. During the scanning of an input channel the assigned analog output assumes an output level proportional to the measured input: more complex output control can be programmed with end-of-scan processing.

Digital outputs can be used for alarm purposes or control outputs, or used, in conjunction with the input signals, for collecting data from external modules. Any alarm output can be assigned to any analog or status input channel.

2.4 ANALOG MEASURING CIRCUIT

Within the SI 3535, analog inputs are measured by an analog-to-digital converter (ADC) which uses a pulse-width conversion technique. Each measurement by the ADC consists of a continuous integration; a choice of different integration times is available, giving a selection of reading rates and measurement resolution. In general, shorter integration times produce faster measurements, but with a reduced scale length. Longer integration times give slower measurements, but with increased sensitivity, and better interference rejection.

3 USER INTERFACES

3.1 SETUP FACILITIES

The **SI 3535D Data Logger** can be fully set up from its front panel.

When a setup function is selected, the display provides a sequence of menus which are associated with each step in the setting-up procedure. Selections from these menus are made by pressing the relevant soft-key located below the display; each soft-key is assigned a different meaning, depending on the display options. Other keys on the control panel are hard keys (i.e. they have specific functions, denoted by the associated engraving).

On models **SI 3535F and SI 3535G**, a VT 220 terminal may be plugged into the front of the unit and used instead of a front panel. (See Chapter 5, Section 2.2.)

All SI 3535 loggers may be remotely controlled by a computer or other intelligent peripheral. This is connected to an appropriate interface socket on the logger rear panel.

3.2 SI 3535D FRONT PANEL

The SI 3535D front panel assembly (Fig 1.1) houses the keypad, LCD display, printer, floppy-disk drive and keyswitch. The display is divided into three areas: results, status icons and soft-key prompts.

The results area provides 80 columns x 22 rows of normal text or 40 columns x 11 rows of double-size text. Resolution of the display is 640 x 200 with cold cathode fluorescent backlighting; control of contrast and vertical viewing angle are provided.

A thermal printer allows copies of the screen display to be printed, in either 80 columns of normal text or 40 columns of double-size text.

The printer also allows copies of the screen in a horizontal format, as well as normal and inverted modes. (See Chapter 5, Section 6.3.)

4 COMPATIBILITY WITH ORION

Every effort has been made to ensure compatibility between Orion and Scorpio, so that, where possible, Orion hardware and software can be transferred to Scorpio. There are, however, some important differences between the two systems, so care should be taken.

Section 4.5 in Chapter 3 highlights the differences between Orion and Scorpio and tells you what you can and cannot do. **One very important point** to note is that the SI 35301D Transducer Energisation Module, used in Orion, must **NOT** be used in Scorpio: otherwise, damage will result both to the energisation module and to Scorpio. Scorpio has its own transducer energisation module, which is the SI 35351D.

5 THE SI 3535 MANUALS

This manual, the SI 3535 User Guide, and its companion volume, the SI 3535 Reference Manual, provide full instruction in the use of the SI 3535 loggers.

The SI 3535 Reference Manual covers the remote control and end-of-scan processing languages, and details the setting up of the remote control interfaces. The scope of the reference manual is summarized in its introduction. The scope of the present manual is summarized below.

5.1 THE SI 3535 USER GUIDE

The aim of the SI 3535 User Guide is to provide *useful* information on how best to employ your SI 3535. To guide you in reading the manual, a synopsis of Chapters 2 through 10 is given below.

***Ch 2**: Measurement Techniques*
Introduces the simple theory behind the measurement of voltage, current, etc, then progresses to an explanation of more advanced measurements, such as strain and temperature. Although intended mainly for newcomers to data logging, some items of interest may be found by most users.

***Ch 3**: Installation*
Describes how to install a Series SI 3535 logger and includes: safety precautions; general procedure for connection and fitting of standard modules; connection of slave units for increased channel handling capacity; rack mounting; renewing the printer paper roll; and ejecting and inserting a floppy disk.

***Ch 4**: Using the SI 3535D*
Explains the general approach to setting up and using an SI 3535D Data Logger from the front panel. A very simple application is used to demonstrate how to set up and run a logging task. Signposts are given to the more advanced uses of the logger.

***Ch 5**: Logger Control Functions*
Gives a concise description of each logger facility, in the order in which the facilities are set up from the "initialized" state. References are given to the equivalent remote control details in the SI 3535 Reference Manual.

***Ch 6**: Conversions and Alarms*
Fully describes measurement conversions such as Scale, Polynomial, etc, and the detection of various types of alarm against user-defined limits.

***Ch 7**: Output Formats*
Describes the format of the results and control information output by the logger.

***Ch 8**: Disk Drive*
Describes how to operate the integral disk drive of the SI 3535D and G.

***Ch 9**: Data Acquisition Modules*
Gives installation details of individual SI 3535 Series Data Logger modules. Expands on the general information given in Chapter 3.

***Ch 10**: Transient Capture*
Describes how to capture transients, with a logger that is equipped with the SI 35351F Transient Capture Module.

Chapter 2
Measurement Techniques

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1 INTRODUCTION

This chapter is intended mainly for newcomers to the data logging scene, or for those whose data logging experience is limited to making a few simple measurements. To give you an idea of what is going on "behind the scenes" the chapter introduces the simple theory behind the measurement of various physical quantities, such as voltage, current and resistance, and progresses from these to more advanced measurements, such as strain gaging. The intention is to give an understanding of the full capability of SI 3535 loggers, and thus enable you to see clearly how such a logger may be used to solve your data logging problems.

The further aim of this chapter is to ensure that your measurement results, obtained with an SI 3535, truly reflect the system being monitored. Although the logger is capable of making extremely accurate measurements, it can measure only what is applied to its inputs. In this chapter you are told how to use the interference rejection abilities of the logger to full advantage: some simple rules also given, which ensure that the signals applied to the input channels are as "clean" as possible.

2 INPUT DATA

The SI 3535 is able to monitor analog signals and digital signals. Digital signals are read directly into the logic circuitry of the logger. Analog signals, however, are converted into digital form by an Analog-to-Digital Converter (ADC) within the logger.

Analog signals represent a continuously variable physical quantity. Some quantities, such as voltage and current, may be measured directly, whilst others, such as temperature and strain, must be converted to electrical form with a transducer. Typical transducers are thermocouples and platinum resistance thermometers (PRTs) for temperature monitoring and resistive elements (connected into a bridge circuit) for strain gaging.

Digital signals are those that are switched between two distinct "logic" states, e.g. +5V for logic "0" and 0V for logic "1". This type of signal is often derived from switch contacts on the system being monitored and represents "status" and "event" conditions. These signals may be monitored singly or in groups, and compared with preset conditions. Other digital signals may be pulse streams whose repetition rate is proportional to a physical quantity: typical transducers that output such signals are flowmeters and shaft speed indicators. The SI 3535 is able to cope with both types of digital signal.

3 MEASUREMENT CONCEPTS

For each each type of measurement that the SI 3535 can make, this section introduces you to the simple theory behind it and guides you in using the technique best suited to your application.

3.1 VOLTAGE MEASUREMENT

The ADC responds to dc and ac voltages. Therefore voltages, and transducers which produce voltage outputs, may be measured directly. Five dc ranges provide for dc voltages from 1µV through 105V, whilst four ac ranges provide for ac voltages from 1µV through 19V. Other electrical quantities, i.e. current and resistance, are measured indirectly, as described in Sections 3.2 and 3.3.

3.2 CURRENT MEASUREMENT

A current (i) is measured by passing it through a resistor of known value (r). By Ohms law, the voltage (v) developed across the resistor is directly proportional to the current. (See Fig 2.1.) This allows the value of current (i) to be computed from the simple equation $i = v \div r$. The logger knows from the "Amps AC/DC" selection in the Channel program menu that it is measuring current, and does this computation automatically to display the result in amps.

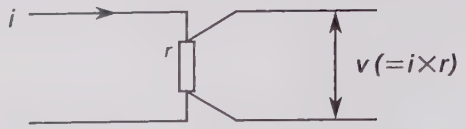


Fig 2.1 *Principle of current measurement.*

Precision 100Ω shunt resistors for the purpose of current measurement are provided in connector block 35303B.

Four dc ranges provide for dc currents from 10nA through 100mA, whilst four ac ranges provide for ac currents from 10nA up to 190mA.

3.3 RESISTANCE MEASUREMENT

The resistance (r) of an external resistor can be measured by passing a constant energizing current of known value (i) through the resistor and measuring the voltage developed across it. Again from Ohms law, the resistance (r) is computed from the equation $r = v \div i$. (See Fig 2.2.) The logger knows from the "Ohms" selection in the Channel program menu that it is measuring resistance, and does this computation automatically to display the result in ohms.

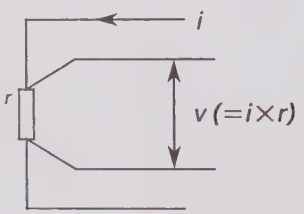


Fig 2.2 *Principle of resistance measurement.*

At the time of selecting "Ohms" measurement you may also select a two-wire or four-wire measurement configuration and define the energization current. (The energization current is provided by the SI 35351D Transducer Energization Module.) The option of thermal drift compensation is also provided.

Two-wire resistance measurement (Fig 2.3) is the simplest in terms of wiring, but it is also the least accurate. Due to the errors introduced by the resistance of the input leads (typically 0.25Ω per metre) this method is suitable only for measurements of resistances above approximately 1 kΩ. A typical error is 1% in 1kΩ. Note that two-wire resistance measurements can be made only with a reed-relay selector (SI 35301K/L).

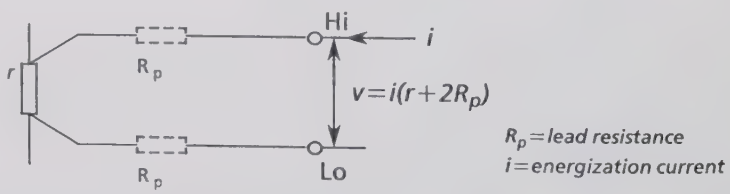


Fig 2.3 *Two-wire resistance measurement connections.*

Four-wire resistance measurement (Fig 2.4) is the standard high accuracy method. Errors due to lead resistance are avoided by routing the energization current through two leads connected to the I_A and I_C terminals and measuring the voltage directly across the unknown resistance. The only disadvantage is that the wiring is slightly more complex.

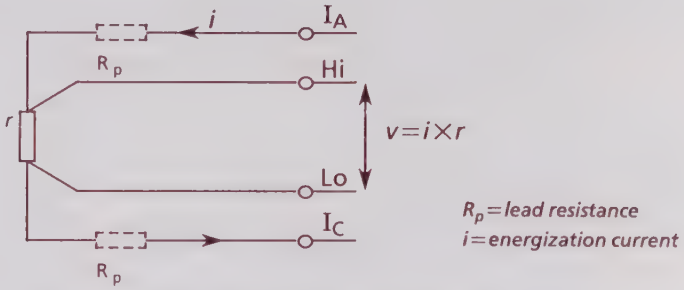


Fig 2.4 *Four-wire resistance measurement connections.*

Where very accurate resistance measurements are required, the four-wire method can be used with thermal drift compensation. This compensates for errors due to parasitic thermocouples. The wiring is the same as for the basic four-wire method, but the measurement takes longer. The logger makes two voltage measurements, one without energization (v) and one with (V): the difference (V–v) is divided by the constant current value (i) to yield the true resistance value. This computation is done automatically, when four-wire resistance measurement with thermal drift compensation has been selected in the Channel program menu. (Note that, with no parasitic thermocouples present, voltage v is zero.)

The resistance measuring ability of the SI 3535 depends on the energization current. With 100µA energization, it is from 10mΩ up to 137kΩ, whilst with 1mA energization it is from 1mΩ up to 13.7kΩ.

3.4 STRAIN MEASUREMENT

Strain measurement is the measurement of the change in shape of a material under stress. The two simplest types of strain are tensile and compressive and it is these to which most strain gages are designed to respond.

Strain is the ratio of two lengths: the change in length (δl) of a test piece and the original length (l). Therefore strain has no dimensions, but, since most strains measured by a strain gage are relatively small, strain is said to be measured in "microstrains" ($\mu\varepsilon$) where one microstrain equals one micron (δl) per metre (l). (Note: a micron equals one millionth of a meter.)

3.4.1 Strain Gages

Strain gages are transducers whose resistance varies under an applied stress. There are two categories, metallic and semiconductor. Metallic gages have a gage factor G ($\delta\Omega/\ \Omega/$ microstrain) of approximately 2: semiconductor gages have a higher gage factor, of approximately 100, but also have a high temperature coefficient which tends to limit their application.

One type of metallic gage commonly used consists of an etched metal foil pattern (Fig 2.5) on a suitable base, e.g. polyester. This is attached to the test piece by a suitable adhesive, e.g. epoxy resin. The actual adhesive used should suit both the sensor and the surface on which it is mounted and due consideration should be given to the humidity, temperature, etc, of the operating environment. Most suppliers should be able to advise you on the most suitable adhesive to use and the method of application.

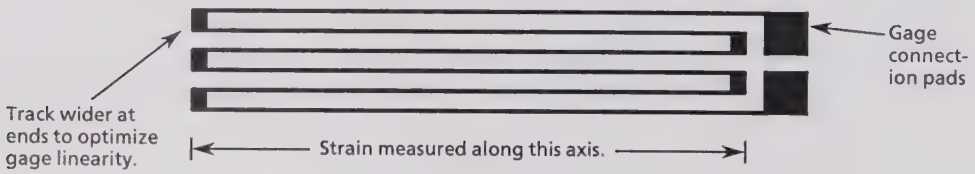


Fig 2.5 *Typical etched-foil strain gage.*

The unstressed resistance (R) of a strain gage (typically 120Ω) equals $\rho l/a$, where ρ is the resistivity of the gage material and l and a are the length and cross-sectional area of the track. When a test piece undergoes strain the gage attached to it is strained by the same amount. Tensile strain causes the gage to stretch, which increases the length of track and reduces the cross-sectional area and thus increases the gage resistance. Compressive strain produces the opposite effect and decreases the gage resistance. This variation in resistance with strain is linear over the operating range of the gage.

3.4.2 Strain Gage Bridges

For strain to be measured it must be translated from a variation in resistance to a variation in dc voltage. This is done by connecting the strain gage into a bridge circuit and energizing the bridge from a constant voltage or constant current supply. (See Figs 2.6 through 2.9.) The reason for having a bridge is that the changes in resistance with strain, especially with a metallic gage, are inherently small and the bridge allows the resultant small changes in voltage to be read directly: strain voltages may thus be measured at the best possible resolution.

Strain gage bridges are often built up, by the user, from individual elements, e.g. the etched-foil strain gage shown in Fig 2.5. (Alternatively, load cells, which work on the same principle, are a complete bridge in themselves.) Each "arm" of a strain gage bridge can be either an active gage or a "dummy". Dummy gages are either an unstressed gage or a resistor of the same resistance as the active gage. The form of a strain gage bridge depends on the application and, to cope with all requirements, the SI 3535 provides for full, half and quarter-bridge configurations.

3.4.3 Temperature Compensation

With regard to strain gaging, temperature variation, in time and/or physical location, can result in three possible sources of error. Fortunately it is possible to compensate for all of these, but care must be taken. The error sources and their compensation are described below, in Sections 3.4.3.1 through 3.4.3.3. When compensation is properly applied all errors due to temperature variation should balance out, so long as the operating conditions of the gage(s) are not exceeded.

3.4.3.1 Differential Expansion

Differential expansion occurs where the change in dimension with temperature of the surface being monitored is different to that of the gage. A temperature rise, for example, could cause the surface being measured to expand by a greater amount than the gage would naturally expand. Since the gage is bonded to the surface it is forced to expand by the same amount and therefore gives a false indication of strain.

This effect can be compensated for in two ways:

(a) by bonding the complete bridge to the surface being measured, in the same temperature environment,

(b) by using temperature-compensated gages.

In a compensated gage it is arranged for the resistivity of the gage material to have a negative temperature coefficient, so that a possible increase in resistance, due to stretching by differential expansion, is cancelled out by a drop in resistivity of the gage material. Temperature compensated gages are designed for use with specific materials, such as stainless steel, mild steel and aluminium.

3.4.3.2 Variation in Gage Resistance

The resistivity of all strain gages tends to vary with temperature, this effect being greater in semiconductor gages than in metallic ones. Thus a change in temperature may alter the gage resistance to give a false strain reading. To compensate for this, all elements of a strain gage bridge should have the same temperature coefficient and be maintained at the same temperature. To minimize heating of the gages an SI 3535 energizes each bridge in turn, just before measurement takes place.

3.4.3.3 Variation in Lead Resistance

The resistivity of the copper-wire leads connecting a strain gage bridge to the logger inputs tend to vary with temperature. However, this effects the strain indication only when the leads are actually included in the bridge network, as in the case in the three-wire quarter-bridge (see Section 3.4.4.4). To compensate, ensure that all input leads included in the bridge network are of the same length and are maintained at the same temperature. To minimize heating of the wires the SI 3535 energizes each bridge in turn, just before measurement takes place.

3.4.4 Which Type of Bridge Should I Use?

The newcomer to strain measurement might justifiably be confused over which type of strain gage bridge best suits a particular application: full-bridge, half-bridge, four-wire quarter-bridge, or three-wire quarter-bridge. This section describes the advantages and possible disadvantages of each type of bridge in turn and should help you to reach a rational decision. Incidentally, the name given to each type of bridge relates to that part of the bridge which is located at the measurement site.

Generally the reason for using a half-bridge rather than a full-bridge, or a quarter-bridge rather than a half-bridge is a financial one: you need less gages and/or leads. There is also the practical reason that, with less gages and/or leads, installation is much simpler and there is less chance of making errors. There are a few trade-offs, however, and these are pointed out in the following bridge descriptions.

3.4.4.1 *Full-Bridge*

The full-bridge (Fig 2.6) uses the most hardware, i.e. four gages, all mounted at the measurement site, and six leads. If you are using a full-bridge device such as a load cell, then this is the only configuration possible. However, if you are using discrete elements such as etched foil strain gages then you have the option of using four active gages to obtain a bridge sensitivity of 4×G or of using less gages (i.e. a half-bridge or a quarter-bridge) but with progressively less sensitivity. (See Section 3.4.5 for gage orientation.)

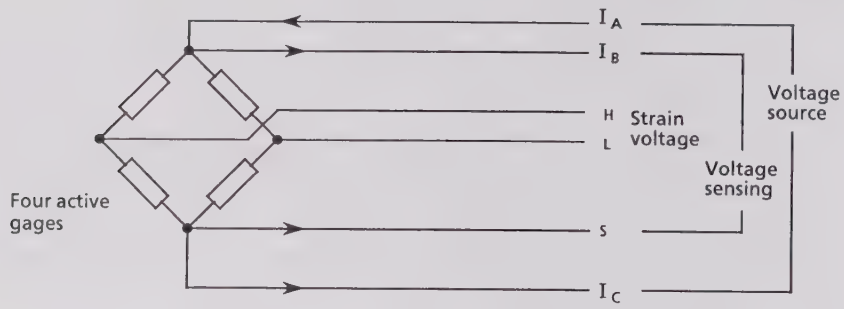


Fig 2.6 *Full-bridge strain gage configuration, voltage energized.*

With regard to temperature compensation ensure that all four bridge elements are mounted on the same material and are maintained at the same temperature. Since the level of voltage energization is sensed at the bridge any variation in lead resistance has no effect on the strain voltage.

3.4.4.2 *Half-Bridge*

The half-bridge (Fig 2.7) uses just two gages, both mounted at the measurement site. Normally, both gages are active, which gives a bridge sensitivity of 2×G. The same number of leads is used, i.e. six, so, compared with a full-bridge, you have a saving of two gages with a trade-off of half the sensitivity.

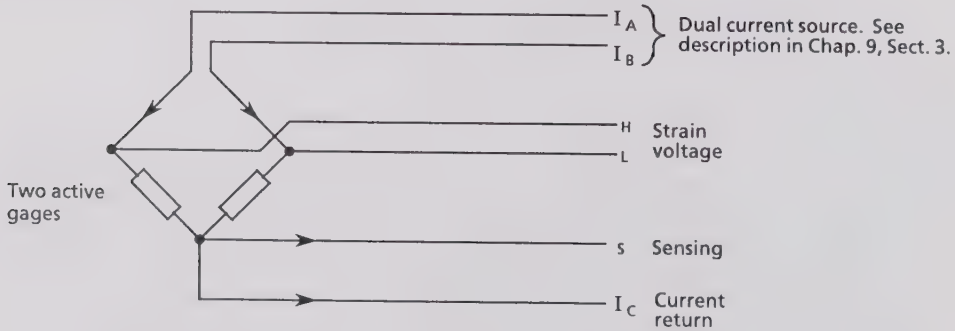


Fig 2.7 *Half-bridge strain gage configuration, current energized.*

With regard to temperature compensation ensure that both bridge elements are mounted on the same material and are maintained at the same temperature. Since the bridge is energized by a dual constant current source any variation in lead resistance has no effect on the strain voltage. The current return at the bottom of the bridge is maintained at 0V to avoid the development of common mode dc interference.

3.4.4.3 *Four-Wire Quarter Bridge*

The four-wire quarter-bridge (Fig 2.8) is a variation of the half-bridge. It uses just one active gage at the measurement site and shares a "common dummy" gage with several other bridges. Thus bridge sensitivity is solely that of the active gage ($\approx$2 for a metallic gage) but the number of lead wires is reduced to four and you need only one gage per channel.

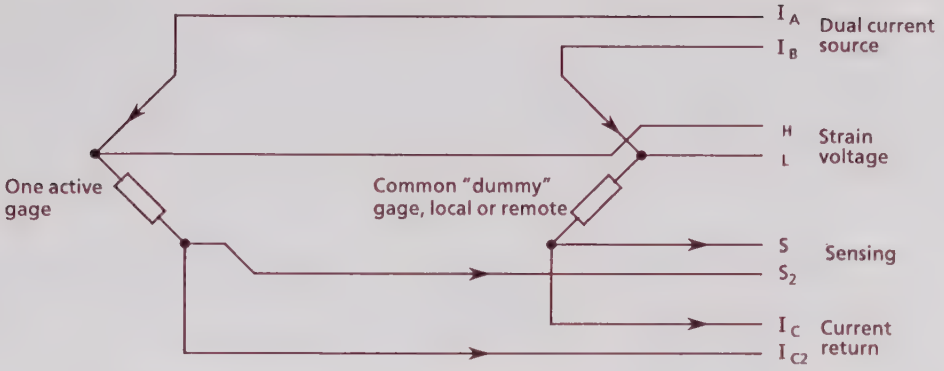


Fig 2.8 Four-wire *quarter-bridge configuration, common dummy.*

To achieve adequate temperature compensation it is important that the common dummy enjoys the same environment as the active gages. In an industrial application this is best done by mounting the common dummy in the same vicinity as its active companions: it is then known as a "local" dummy.

An SI 3535 also gives the option of using a "remote" common dummy, connected at the logger. This configuration could give problems with ordinary gages, due to the difficulty of ensuring that the environment of the remote dummy is the same as that of the active gage(s). However, with temperature compensated gages the problem is reduced to ensuring that the temperature of the remote dummy (which can be a good quality resistor) is reasonably stable. Since the 0V current return for the active gage is sensed at the gage, and the 0V current return for the common dummy is sensed at the dummy, the difference in lead lengths and any variation in lead resistance do not effect the strain voltage.

3.4.4.4 Three-Wire Quarter Bridge

The three-wire quarter-bridge (Fig 2.9) is another variation of the half-bridge. It is similar to the quarter-bridge described above, but with some important differences. The plus point is that the number of leads is reduced to three, but a dummy gage is required for each bridge and is always mounted remotely.

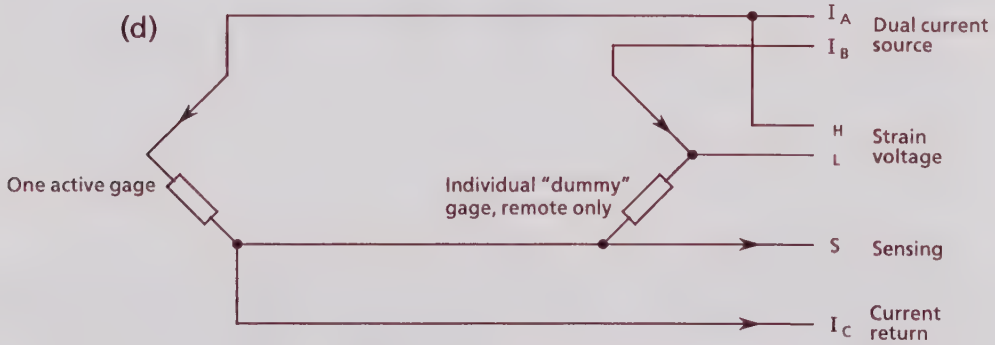


Fig 2.9 *Quarter-bridge, three-wire strain gage.*

The resistance of two of the leads (i.e. those connecting I_A current and Sense) is included in the bridge. Therefore, to balance the bridge, the leads should be of equal length. With regard to temperature compensation the leads should be routed alongside each other, so that any variation in lead resistance cancels out. With regard to bridge sensitivity the lead resistance should not be so high as to reduce the sensitivity unduly.

The comments in Section 3.4.4.3 regarding the use of a remote common dummy apply equally to the three-wire quarter-bridge.

3.4.5 Strain Gage Orientation

It is important that strain gages are correctly orientated on the surface(s) to be measured. In the example shown in Fig 2.10 gages A and D are under tension, whilst gages B and C are under compression: the bridge configuration shown allows the gage factors to add up to a combined sensitivity of 4×G.

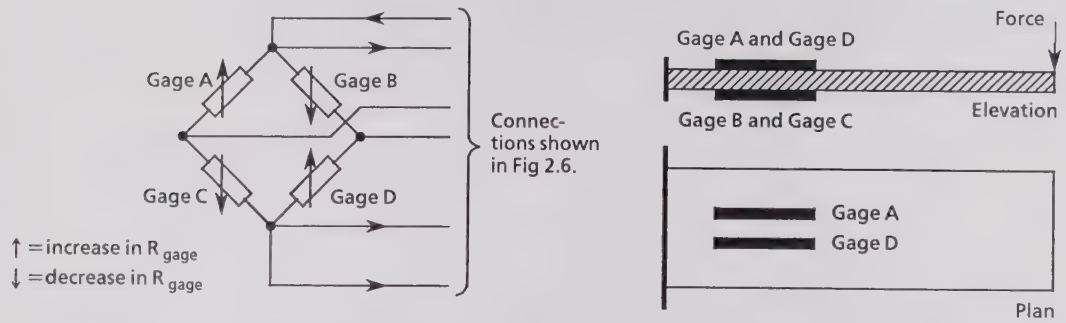


Fig 2.10 *Example of strain gage orientation.*

Note that dummy gages bonded to the measured surface are mounted at right angles to the active gage(s), i.e. to the line of stress.

The two gages in a half-bridge are similarly orientated. For example, gages C and D in Fig 2.10 could be orientated in the same way in a half-bridge.

3.4.6 Bridge Initialization

All strain measurements are referenced to the zero stress condition. Since strain gage bridges rarely have zero output for zero load, trimming resistors are sometimes employed to balance the bridge. This method is fine for simple systems with only one or two bridges, but is impractical for large systems. The SI 3535 avoids the necessity of using trimming resistors by measuring the zero load output and subtracting this from the loaded output.

With zero stress applied, each bridge is "initialized" with the Init Chan facility of the PROGRAM menu and this causes the logger to store the small strain voltage (v) for zero load. When stress is applied, the change in strain gage resistance alters the balance of a bridge and produces a voltage V proportional to strain. The logger computes the true strain value from the voltage difference $V–v$, and other parameters such as the gage factor.

3.4.7 Bridge Energization

Bridge energization in the SI 3535 is provided by the SI 35351D Transducer Energization Module. This can be configured to provide constant voltage energization for a full-bridge arrangement, or constant current energization for a half-bridge or quarter bridge arrangement. (See Chapter 9 for details.)

The range of strain that an SI 3535 is able to measure depends on the gage you are using. The transducer energization module is designed to cope with the energization requirements of all commonly used gages. The resolution, repeatability and limits of error obtained with the various types of bridge, are given in the Specification in Appendix A of the manual.

3.5 TEMPERATURE MEASUREMENT

To enable the logger to measure temperature, a temperature sensor must be used. This converts the thermal energy into an electrical signal that the logger can recognise. The SI 3535 allows you to measure temperature with either a thermo-couple or a platinum resistance thermometer (PRT). To help you decide which one to use, Table 2.1 compares their overall performances. Note that PRTs are also known as RTDs (resistance thermometer devices).

Table 2.1 Performance Comparison: PRTs v Thermocouples

Aspect	Resistance Thermometer	Thermocouple
Range	–200°C to 850°C	–250°C to 2000°C
Accuracy	±0.1°C to ±1°C	±0.5°C to ±5°C
Stability	Excellent: output consistent with temperature over very long periods.	Tendency to drift, type K in particular.
Response time	1sec to 50secs.	0.05sec to 5secs.
Vibration tolerance	Not as tolerant of vibration as thermocouples generally, but "supported" types are available for industrial use.	Mineral insulated types suitable for arduous operation.
"Noise" susceptability	Less susceptible to electrical interference than thermocouples.	More susceptible to electrical interference than PRTs.
Size	Resistance thermometers, generally, are larger than thermocouples.	Some very small thermocouples are available.
Cost	A PRT normally costs between two and three times as much as a thermocouple of similar performance.	Thermocouples are cheaper: see opposite column.
Leads required	Ordinary copper leads.	To avoid errors, the leads between the measuring junction and the reference junction(s) should be of the same (or similar) metals as those used in the thermocouple.

A wide selection of temperature sensors is available, to suit all measurement environments. Full details can be obtained from the sensor manufacturers. Most manufacturers will also provide you with detailed information on how to install and use your chosen sensor to get the most accurate results. Sections 3.5.1 and 3.5.2 give basic guidance on the use of PRTs and thermocouples.

3.5.1 Using a PRT

A PRT uses the principle that the resistance of a platinum wire varies predictably with temperature. Therefore the connections made to the logger are the same as those for resistance measurement. An SI 35351D module is required, to energize the PRT.

To ensure an accurate result, four-wire PRTs are used. The color coding of the leadwires (Fig 2.11) is that recommended by the British Standard BS1904:1984. However, not all manufacturers adhere to this standard, so be careful. If in doubt, refer to the manufacturer's data sheet. Do not use four-wire *compensated* PRTs: these have leadwires color-coded blue, blue, red, and white and are *not* suitable for use with the SI 3535.

For a PRT to give a true indication of temperature it should be placed in good thermal contact with the substance being investigated. Insertion probes should be inserted into the liquid, gas, etc, the distance recommended by the manufacturer. Surface probes should be mounted with a small amount of heat sink compound between the probe and the surface. See Fig 2.12.

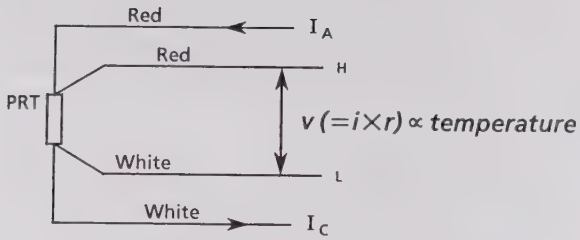


Fig 2.11 *Temperature measurement with a PRT.*

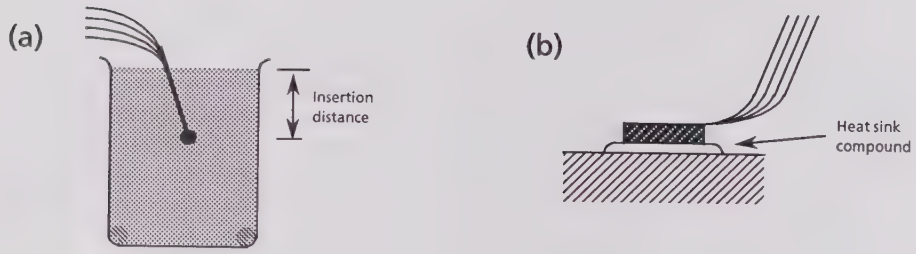


Fig 2.12 *Installing a PRT: (a) insertion type; (b) surface-mounted type.*

The SI 3535 provides for linearization of a PRT output to conform with the IEC 751 Standard. PRT temperature readings are available over two ranges, –200°C to 300°C and 300°C to 600°C, with the error in conformity and repeatability given in the Specification in Appendix A of the manual.

3.5.2 Using a Thermocouple

A thermocouple is simply a junction between two dissimilar metals, which develops an emf proportional to its temperature. A simple thermocouple can be made by twisting two suitable wires together, but, generally, it is best to use one of the purpose-built temperature "sensors" available from thermocouple manufacturers.

The principle of thermocouple measurement is illustrated in Fig 2.13. Here it can be seen that a thermocouple circuit consists basically of a pair of thermocouple junctions connected in opposition (i.e. the two emfs they produce act against each other). Since the two junctions are of the same type they produce equal emfs when held at the same temperature —in which case the resultant emf is zero. If the measurement junction is now heated (to 100°C for example) whilst the reference junction is maintained at 0°C, then the resultant emf is a function of the two temperatures. This principle applies for all thermocouple measurements and a wide selection of temperature sensors allows you to measure temperatures in the range –250°C through 2000°C.

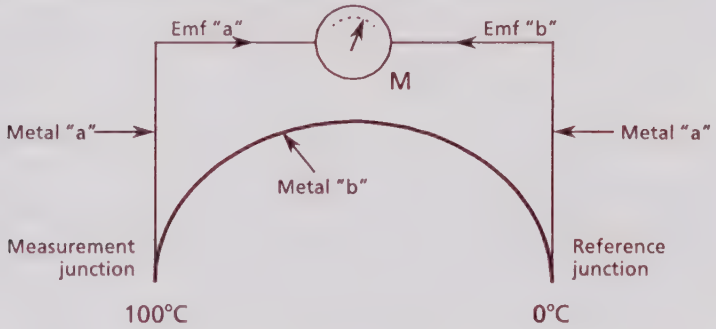


Fig 2.13 *Thermocouple principle.*

Historically, the two thermocouple junctions are known as the "hot" and "cold" junctions, the cold junction being maintained at 0°C by a flask of melting ice. Recently, however, the two junctions have come to be known, more correctly, as the "measurement" and "reference" junctions. (When temperatures lower than 0°C are being measured the "hot" junction is cooler than the "cold" junction!)

Thermocouples may be connected to the SI 3535 in two different ways. One of these (Fig 2.14) uses an external reference unit, whilst the other (Fig 2.15) uses the logger input connections themselves as reference junctions. In the latter case the ambient temperature of the input terminals is monitored in the connector block and temperature compensation is applied automatically. (In these practical measuring circuits there are, of course, two reference junctions, one at the Hi input terminal and one at the Lo; but, since these two closely located terminals have a common temperature, they act as a single junction.)

Note the use of compensating/extension cables to connect the thermocouple sensor to the reference junctions. These cables contain single or multiple pairs of wires whose composition is the same as, or similar to, that of the sensor metals and this allows the measurement and reference junctions to be situated a suitable distance from each other. Use only those cables recommended by the thermocouple manufacturer, and make sure that they are connected the right way round. Most cables are color-coded to allow you to identify the positive and negative wires, but, be careful, the color codes vary from country to country. Thermocouple terminations are either color-coded in the same way or marked "+" and "–".

The SI 3535 is able to operate with eight different types of thermocouple, i.e. types B, E, J, K, N, R, S, and T. All measurement results are linearized to comply with the IEC 584 and BS 4937 Standards. The different temperature ranges thus made available are listed in Table 2.2.

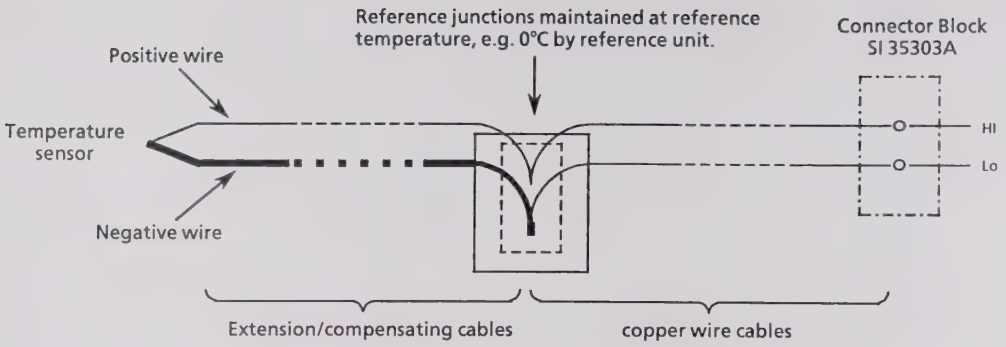


Fig 2.14 *Thermocouple connections, made via a reference unit.*

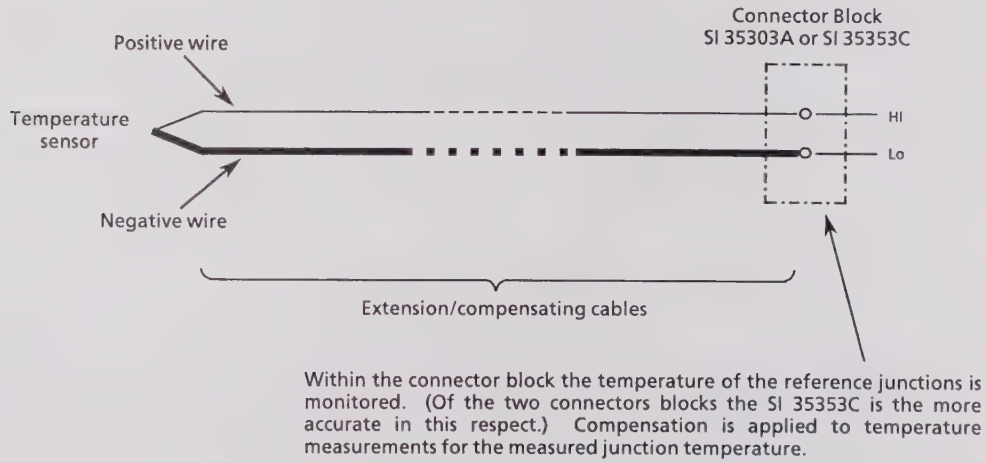

Connector Block SI 35303A or SI 35353C
Positive wire
Temperature sensor
Negative wire
HI
Lo
Extension/compensating cables
Within the connector block the temperature of the reference junctions is monitored. (Of the two connectors blocks the SI 35353C is the more accurate in this respect.) Compensation is applied to temperature measurements for the measured junction temperature.

Fig 2.15 *Thermocouple connections, made directly to the logger.*

Table 2.2 Thermocouple Ranges

Thermocouple Type	Overall Temp. Range (°C)
B	80 to 1820
E	–200 to 1000
J	–210 to 1200
K	–210 to 1372
N	–250 to 1300
R	0 to 1767
S	0 to 1767
T	–210 to 400

Full details of the individual temperature ranges of the SI 3535 are given in the Specification in Appendix A.

3.6 FREQUENCY MEASUREMENT

Up to five independent channels on an SI 35302C Counter-Timer Module can be used for frequency measurement up to 400 kHz. This provides for the pulse streams produced by flow meters and shaft speed indicators. It is also possible to measure the related parameters such as time period and pulse width.

The period facility is especially useful for obtaining a satisfactory resolution in the measurement of low frequencies. After the period is measured a Reciprocal Conversion, available under the PROGRAM menu, is used to compute the frequency.

3.7 QUALITY OF MEASUREMENT

The quality of a measurement is expressed in terms of resolution and accuracy. To appreciate the measurement ability of the SI 3535 it is important not to confuse these two terms. Therefore, a concise definition of each one is now given. Also defined is the term "repeatability", which is another important aspect of measurement quality.

3.7.1 Resolution

Resolution describes the "fineness" of a measurement. In other words, it is the smallest amount by which your measurement result can change. As an example, the SI 3535 is able, on its 100mV dc input range, to measure dc voltages with a resolution of 1µV, i.e. one millionth of a volt. Thus you can measure voltages of 0.001mV, 0.002mV, 0.003mV, etc. up to around 100.001mV. Similarly, on the 100V dc range voltages can be measured with a resolution of 10mV, e.g. 50.01V, 50.02V, etc. (These figures assume an integration time of 5ms: for integration times of 20ms and 80ms, finer resolutions can be obtained.)

3.7.2 Accuracy

Accuracy describes how closely the measured value approaches the actual value of a physical quantity. Accuracy is quoted in the SI 3535 Specification in terms of "Limits of Error" and, for this reason, it is sometimes known as the "uncertainty" of a measurement. As an example, the limits of error on all dc voltage ranges, from 10mV to 10V, with a 20ms or 80ms integration period, are "$< \pm[0.005\% + 2$ digits $+ 1\mu V]$". This means that if your measurement result (measured on the 10V range, with an integration time of 5ms) is 3.150V then the actual value is somewhere in the range of values represented by $3.15V \pm 2.1585mV$.

The limits of error in the SI 3535 Specification are quoted for one year after calibration, and are applicable after a one hour warm-up period and with an ambient temperature of $20°C \pm 3°C$. For ambient temperatures other than this a temperature coefficient must be taken into account. (See the SI 3535 Specification in Appendix A of the manual.)

3.7.3 Repeatability

Repeatability is an aspect of measurement quality that is particularly important when measurements are being compared with each other, rather than against an absolute standard such as the Standard Volt. Repeatability means that successive measurements of a stable physical quantity remain substantially the same over long periods, assuming a stable ambient temperature. This ensures that, even if the SI 3535 is slightly out of calibration (after periods in excess of one year) the results of differential measurements are valid.

4 COMBATING INTERFERENCE

"Interference" is a general term for anything that influences a signal being measured to give a false result. Usually the interference takes the form of an extraneous signal, which combines with the signal being measured at the ADC input. Sometimes, however, errors in the result may be caused by a variation in performance with temperature (also known as "drift").

Depending on the type of measurement being made, the SI 3535 is able to reject specific types of interference, whilst accepting the signal to be measured. It is still an advantage, however, to ensure that the signal being measured is as free of interference as possible. This is achieved by careful installation of sensors and input leads, as outlined in Section 4.6 in this chapter.

4.1 TYPES OF INTERFERENCE

Interference can be classified as follows:

(a) in the way it appears at the input terminals, *common mode* or *series mode*, and

(b) the interference content, dc or ac.

Common mode interference occurs when the interference source e_{cm} is common to the Hi and Lo inputs of the logger. This situation is shown in Fig 2.16.

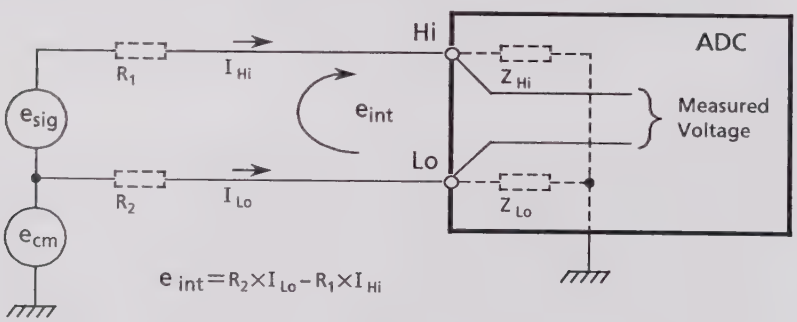


Fig 2.16 *Common mode interference.*

Common mode interference does not affect the measurement directly. If the input impedances Z_{Hi} and Z_{Lo} were equal, and the lead resistances R_1 and R_2 equal also, common mode interference would have no effect: the lead and input impedances would form a balanced bridge and, therefore, no voltage due to the interference e_{cm} would appear across the Hi and Lo inputs. In practice, however, the input impedances Z_{Hi} and Z_{Lo} are different, Z_{Lo} generally being the lowest. This imbalance results in an interference signal e_{int} ($=R_2 \times I_{Lo} - R_1 \times I_{Hi}$) across the Hi and Lo inputs, and common mode interference is thus converted into *series mode* interference. A high resistance in the Lo input lead generally aggravates the problem.

In the SI 3535 the problem of common mode interference has largely been solved by using floating inputs. Section 4.2 gives the details.

Series mode interference acts in series with the signal being measured (the "wanted" signal e_{sig}). This type of interference may be due either to common mode interference, as explained above, or to interference mixed with e_{sig}. The way in which series mode interference is dealt with is explained in Sections 4.3 and 4.4.

4.2 COMMON MODE REJECTION

In the SI 3535 common mode interference is rejected by using a floating analog-to-digital converter (ADC), as shown in Fig 2.17.

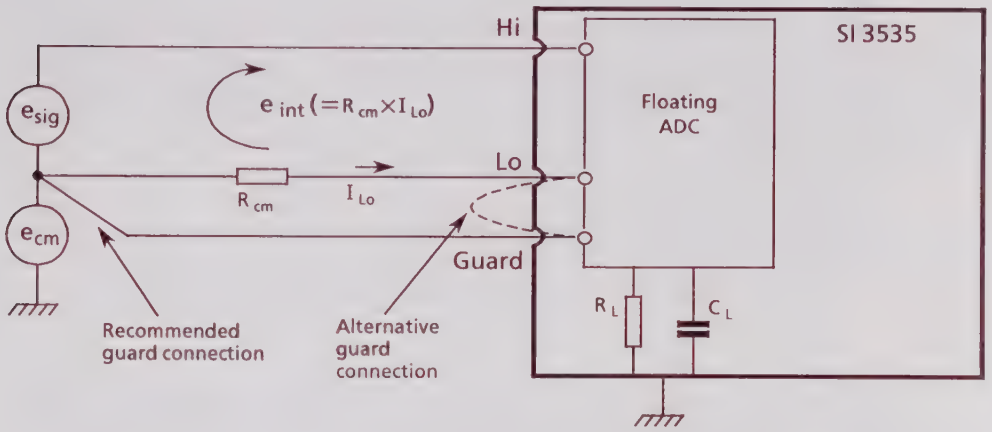


Fig 2.17 *The use of a "floating" ADC for common mode rejection.*

The best rejection of common mode interference is obtained with Guard connected to the source of common mode. Should this be impractical then guard must be connected to Lo. With the latter method, common mode and series mode rejection is slightly degraded, due to the minute leakage through R_L and C_L (the leakage resistance and stray capacitance).

Note that a maximum value for the common mode voltage is dictated by the analog input modules: the maximum voltage to ground permitted at the inputs to these modules is ±150V for the SI 35351Q/H, ±14V for the SI 35301J, and ±200V for the SI 35301K/L. Any leakage to ground at these voltages is negligible.

As explained in Section 4.1, common mode interference is measurable only when converted to series mode interference. It is standard practice, therefore, to deliberately insert a resistance R_{cm} of known value into the Lo input lead when common mode rejection is measured during tests on the logger's ADC. The common mode rejection figures for the SI 3535 (see Table 2.3) are specified for an R_{cm} value of 1kΩ. Usually, the resistance of the Lo input lead is much less than 1kΩ, in which case the rejection is correspondingly greater. (Conversely, the common mode rejection will be less than that specified if the resistance of the low input lead is greater than 1kΩ!)

Table 2.3 Common Mode Rejection

Input Module and Type of Interference	Rejection	
	20ms Integ.	80ms Integ.
Reed relay (35301K/L), High Voltage Solid State (35301K/L)		
dc	>140dB	>140dB
50Hz/60Hz	>130dB	>140dB
High Speed Solid State (35301J)		
dc	>130dB	>130dB
50Hz/60Hz	>120dB	>120dB

These figures assume that the guard terminal is connected to source and that there is 1kΩ imbalance in the input leads.

Note that the common mode rejection of ac signals decreases as the frequency increases.

4.3 AC SERIES MODE REJECTION

The term *series mode rejection* is generally applied to the rejection of line frequency interference (50/60Hz), when this is acting in series with a "wanted" dc signal. The SI 3535 rejects series mode interference by *integrating* each dc measurement over a complete number of cycles of interference. Integration means continuously monitoring the input signal over the measurement period and computing the mean value. During this process the ac interference averages to zero. Measurement integration is phase-locked to the fundamental frequency of the line voltage and hence rejects interference at this frequency.

Ac series mode rejection is effective when the logger is set to make either forty measurements per second (20ms integration time) or ten measurements per second (80ms integration time). See Fig 2.18.

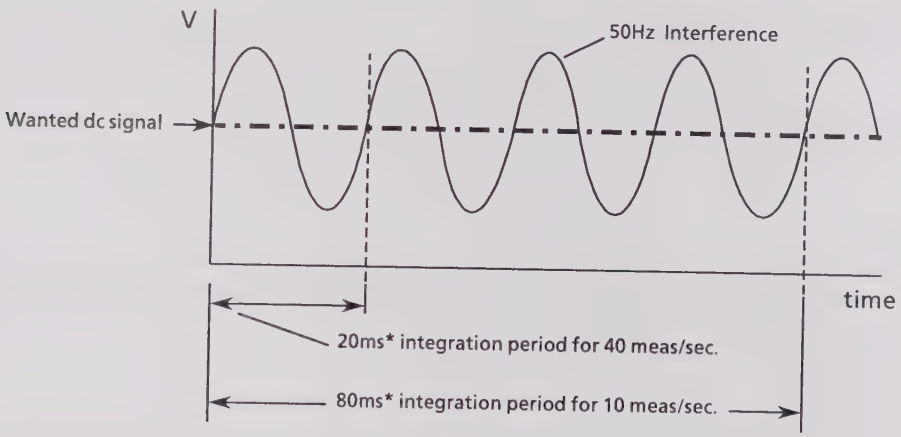

V
50Hz Interference
Wanted dc signal
time
20ms* integration period for 40 meas/sec.
80ms* integration period for 10 meas/sec.
*The ADC automatically adjusts the integration times to 16.67ms and 66.67ms when the 3535 is used with a 60Hz supply.

Fig 2.18 *The rejection of ac series mode interference at 50Hz.*

An integration period of 20ms gives a series mode rejection of >60dB at 50Hz and its harmonics. An integration period of 80ms gives a series mode rejection of >70dB at 50Hz, its harmonics and some subharmonics. Series mode rejection is not effective for either of the measurement rates 100 meas/sec or 500 meas/sec. Therefore, in electrically noisy environments it is essential to measure at 40 meas/sec or 10 meas/sec.

Note that the wanted dc signal *plus* ac interference may require a higher input range than the wanted signal alone. If ac interference is unavoidably present at the logger input, measure it on an ac voltage range, then select a dc voltage range that can accommodate it. (When doing this, don't forget to convert the rms value of the ac interference to a peak value, i.e. Vpeak = 1.4Vrms.)

Note also that the rejection of series mode ac interference is applicable only to dc measurements. Therefore, with ac measurements, it is essential that all precautions are taken to avoid ac interference: some recommendations for this are given in Section 4.6 in this chapter.

4.4 DC SERIES MODE REJECTION

If series mode *rejection* of dc interference is required for ac measurements, then a capacitor must be inserted into the Hi input to the ADC.

4.5 THERMAL COMPENSATION

Small errors in measurement results can be caused by parasitic thermocouples in the measuring circuit. These may be actually inside the logger or included in the sensor connections.

The SI 3535 provides thermal compensation for all measurements involving energized sensors, i.e. ohms, PRT and strain gage measurements. For each of these the logger makes two measurements, the first with no energization and the second with energization. Thus the first measurement (v) is entirely due to thermal voltages, whilst the second (V) is due to the thermal voltages *plus* sensor energization. By storing v and subracting it from V the logger is able to obtain a true measurement result.

Thermal compensation may be selected for ohms, PRT or strain gage measurements individually. Should the effect of parasitic thermocouples be negligable or unimportant then compensation may be switched off to increase the measurement rate.

4.6 DRIFT COMPENSATION

Variations in measurement results, known as "drift", can be caused by changes in the internal temperature of the logger, which in turn affect the performance of the ADC*. To compensate for this, the logger, with drift compensation on, measures two reference inputs and calculates from the results actually obtained the compensation to be applied for all readings. Compensation is applied every five seconds.

Drift compensation can be switched on or off by remote command only. The precision of meaurement results, as given in the SI 3535 Specification, is guaranteed only for measurements made with drift compensation on. If it is absolutely necessary to obtain the maximum possible measurement rate then drift compensation can be switched off to obtain this. However, it is wise to reinstate drift compensation periodically, e.g. every five minutes, to obtain some degree of compensation. The period should reflect the possible variation in the internal temperature of the logger, *which may not be the same as the variation in the ambient temperature.*

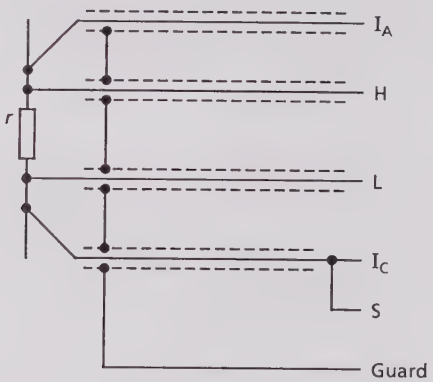
**Analog-to-digital converter.*

Section 4 continues overleaf.

4.7 AVOIDING INTERFERENCE

To avoid **ac** interference:

- Use twisted pairs or screened leads to connect the measured signal to the logger input connectors.
- Avoid running the input leads near other cables carrying heavy ac currents or high ac voltages.
- For ohms measurements, particularly on the high ranges, use screened leads connected as follows:



To avoid **dc** interference:

- Keep the input lead resistance as low as possible, i.e. use short, thick leads.
- Try to avoid sources of thermal emf, such as nickel-iron relay contacts with copper connections.
- Avoid high humidity, which can cause leakage across nominally good insulators.
- Avoid moisture on exposed terminals, which may cause emfs to be generated by a corrosion process.
- Do not fix cables to vibrating equipment, otherwise electrostatic potentials may be generated.

Chapter 3
Installation

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SAFETY PRECAUTIONS

The equipment described in this manual has been designed in accordance with IEC publication 348 (Class 1) Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. To avoid injury to an operator or service technician the safety precautions given below, and throughout the manual, must be strictly adhered to, whenever the equipment is operated, serviced or repaired. The equipment is designed soley for electronic measurement and should be used for no other purpose. Solartron Instruments accept no responsibility for accidents or damage resulting from any failure to comply with these precautions.

GROUNDING

To minimize the hazard of electrical shock it is essential that the equipment is connected to a protective ground whenever the power supply, measurement or control circuits are connected, even if the equipment is switched off. The protective ground for ac and dc supplies is connected separately.

AC GROUND is connected via the ac supply cord. The cord must be plugged into an ac line outlet with a protective ground contact. When an extension lead is used, this must also contain a ground conductor. Always connect the ac supply cord to the supply outlet before connecting the control and signal cables; and, conversely, always disconnect control and signal cables before disconnecting the ac supply cord. The ac ground connection must have a continuous current rating of 6A.

DC GROUND is connected via a ground stud on the equipment power supply unit (PSU). The dc ground conection must have a continuous current rating of 35A.

Where both protective grounds are used it must be ensured that these grounds are, and will remain, at the same potential.

AC SUPPLY VOLTAGE

Before switching on the equipment ensure that the ac voltage selector is set to correspond with the local ac supply voltage.

Never operate the equipment from a line voltage or frequency in excess of that specified for the voltage selector setting used. Otherwise, the insulation of internal components may break down and cause excessive leakage currents.

FUSES

Before switching on the equipment check that the fuses accessible from the exterior of the equipment are of the correct rating. The rating of the ac line fuse must be in accordance with the voltage of the ac supply.

Should any fuse continually blow, do not insert a fuse of a higher rating. Switch the equipment off, clearly label it "unserviceable" and inform a service technician.

EXPLOSIVE ATMOSPHERES

NEVER OPERATE the equipment, or any sensors connected to the equipment, in a potentially explosive atmosphere. It is NOT intrinsically safe and could possibly cause an explosion.

Continued overleaf.

SAFETY PRECAUTIONS *(continued from previous page)*

SAFETY SYMBOLS

For the guidance and protection of the user, the following safety symbols appear on the equipment:

SYMBOL	MEANING
	Refer to operating manual for detailed instructions of use.
	Hazardous voltages.
	Protective conductor terminal. This must be connected to ground before operating the equipment.

NOTES, CAUTIONS AND WARNINGS

For the guidance and protection of the user, Notes, Cautions and Warnings appear throughout the manual. The significance of these is as follows:

NOTES	highlight important information for the reader's special attention.
CAUTIONS	guide the reader in avoiding damage to the equipment.
WARNINGS	guide the reader in avoiding a hazard that could cause injury or death.

AVOID UNSAFE EQUIPMENT

The equipment may be unsafe if any of the following statements apply:

- The equipment shows visible damage.
- The equipment has failed to perform an intended operation.
- The equipment has been subjected to prolonged storage under unfavorable conditions.
- The equipment has been subjected to severe physical stress.

If in any doubt as to the serviceability of the equipment, don't use it. Get it properly checked out by a qualified service technician.

LIVE CONDUCTORS

When the equipment is connected to its measurement inputs or supply, the opening of covers or removal of parts could expose live conductors. The equipment must be disconnected from all power and signal sources before it is opened for any adjustment, replacement, maintenance or repair. Adjustments, maintenance or repair, must be done only by qualified personnel, who should refer to the Maintenance Manual.

EQUIPMENT MODIFICATION

To avoid introducing safety hazards, never install non-standard parts in the equipment, or make any unauthorized modification. To maintain safety, always return the equipment to Solartron Instruments for service and repair.

1 INTRODUCTION

This Chapter describes the installation procedures to be completed before using the SI 3535 and its associated slave units in a specific application. Details are given of the following:

- Connection and switch-on of power supplies for both ac and dc operation.
- Language configuration.
- Connection and fitting of standard modules.
- Connection of slave units for increased channel handling capacity.
- Rack mounting options.
- Renewing the printer paper roll.
- Ejecting and inserting a disk.

2 POWER SUPPLIES

The SI 3535 can be powered from a supply of 90V to 132V ac or 180V to 264V ac (47Hz to 63Hz), or from a dc supply of 12V to 32V dc (30A). In the event of failure of the ac power, operation of the SI 3535 continues from the dc source without interruption.

2.1 CONNECTION PROCEDURE

1. Set the voltage selector on the PSU (Fig 3.1) to 115V or 230V as appropriate.

2. Ensure that the ac line fuse rating is correct: 2A SLO-BLO for 230V; 5A SLO-BLO for 115V.

3. Ensure that the ac line switch on the PSU is set to OFF.

4. Connect the line lead, to the ac line supply.

5. Connect a switched dc-supply to the DC SOURCE, and a suitable grounding point for use with the dc source.

   CAUTION:

   1. The dc supply is not controlled by the rear-panel ON/OFF switch, and an isolating switch must be provided in the dc supply circuit.

   2. Since the dc supply is of a low voltage, the currents drawn are high. Therefore the supply leads should be of an adequate thickness (i.e. of low resistance). The dc current drawn at switch-on is 50A. So, taking as an example a total lead resistance of 0.1 ohms, 5V is dropped across the leads: for the logger to start in this case necessitates a 15V dc supply.

2.2 MEMORY-SUPPORT BATTERY SWITCH

Ensure that the memory support battery switch (Fig 3.1) is set to ON.

2.3 SWITCHING-ON PROCEDURE

Ensure that the safety covers are fitted over all the input/output terminations, and proceed as follows:

1. Set the ac line switch on the power supply rear panel to ON.

2. Set the front panel keyswitch to the ON position.

2.4 VENTILATION REQUIREMENTS

1. The unit must be installed so that airflow through the cooling slots is possible.

2. *Bench Use* : The unit should be located on a hard surface so that cooling air can flow beneath it. Do not place objects on top of the unit which will block cooling vents and restrict the airflow.

   Avoid sitting the unit above, or near to, other equipment which dissipates a significant amount of heat.

   The spacing between the logger and other equipment above or below it should be a minimum of 20mm. (In normal use this spacing is provided by the feet.)

3. *Rack Use* : The recommended spacing between the logger and other equipment in the rack is 25mm (20mm minimum).

   Mount the logger below other equipment which dissipates significant power.

   The designed airflow is from bottom to top of the logger. Any forced cooling provided by the rack should complement this.

3 LANGUAGE CONFIGURATION

The SI 3535 can be configured to operated in any one of four Language modes: British English, French, American English and German. This principally effects the front panel Menu system and the presentation of dates and numbers. The default language is determined by the setting of two switches on the rear panel of the Controller module. (See Table 3.1 and Fig 3.1.) The switches are read by the SI 3535 on power-up, and during a Device Clear.

3.1 LANGUAGE VARIATIONS

There are a few differences between the language variants for the SI 3535. These are listed below :

Front Panel Menus and Softkeys : use appropriate language.

Date Formats: In American English mode, the date format is mm-dd-yy for both input and output. All other languages use dd-mm-yy.

Number Format: The decimal point marker is a "." (fullstop) for British English and American English, and a "," (comma) for French and German.

Where two non-integers must be entered (as in the conversion command) the separator between them should be a ";" (semi-colon). However, for British English and American English, the "," (comma) may also be used. This maintains compatibility with Orion.

Temperatures: For American English, temperatures are output in °F. For all other languages, °C is used. However conversions are available to alter the units if you prefer.

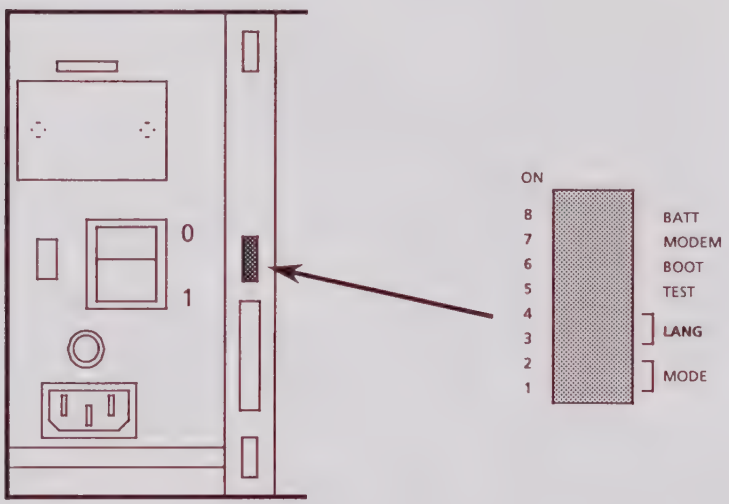

Fig 3.1 *Location of language select switches (4 and 3).*

Table 3.1 Language Select Switch Settings

Switch Settings		Language
Switch 3	Switch 4	
ON	ON	British English
ON	OFF	French
OFF	ON	American English
OFF	OFF	German

4 SI3535 MODULES

To avoid overburdening the present chapter with information that may not necessarily be required, the installation instructions for each module are contained in module-related sub-sections, either in this manual or in the SI 3535 Reference Manual.

The modules that can be fitted in an SI 3535 are listed in Table 3.2. For each module the table gives the number(s) of the mainframe "slot"(s) into which the module may be inserted, and the installation reference. The numbering of the mainframe slots is shown in Fig 3.2.

Table 3.2 SI 3535 Modules

Module	Slot No.	Installation Ref.
Controller.	2	Ref. Man.
SI 35304A GPIB Interface.	3	Ref. Man.
SI 35304B Dual Port RS232/RS422 Interface.	3	Ref. Man.
SI 35301A‡ Reed Relay Input Selector.	4–13	Ch. 9, Sect. 2
SI 35301B‡ Solid State Input Selector.	4–13	—"—
SI 35351C‡ High Voltage Solid State Input Selector.	4–13	—"—
SI 35301E Analog Output Module.	4*	Ch. 9, Sect. 7
SI 35302B Digital Input/Output Module.	4–13	Ch. 9, Sect. 5
SI 35302C Counter Timer Module.	4†	Ch. 9, Sect. 6
SI 35302A‡ Event Status Input Module.	4–13	Ch. 9, Sect. 4
SI 35351D Transducer Energization Module	14	Ch. 9, Sect. 3
SI 35351F Transient Capture Module	4–13 (any adjacent pair)	Ch. 10, Sect. 2

* Preferred slot: can go in slots 4–8 if more than one 35301E Module.
† Preferred slot: can go in slots 4–8 if more than one 35302C Module.

‡ These modules are always used with an input connector, the combined product being identified by an appropriate product number:

SI 35301A + SI 35303A connector = SI 35301L Reed Relay Scanner.
SI 35301A + SI 35353C connector = SI 35301K Reed Relay Scanner.
SI 35301B + SI 35303A connector = SI 35301J High Speed Solid State Scanner.
SI 35351C + SI 35303A connector = SI 35351G High Voltage Solid State Scanner.
SI 35302A + SI 35303A connector = SI 35302D Event-Status Module.

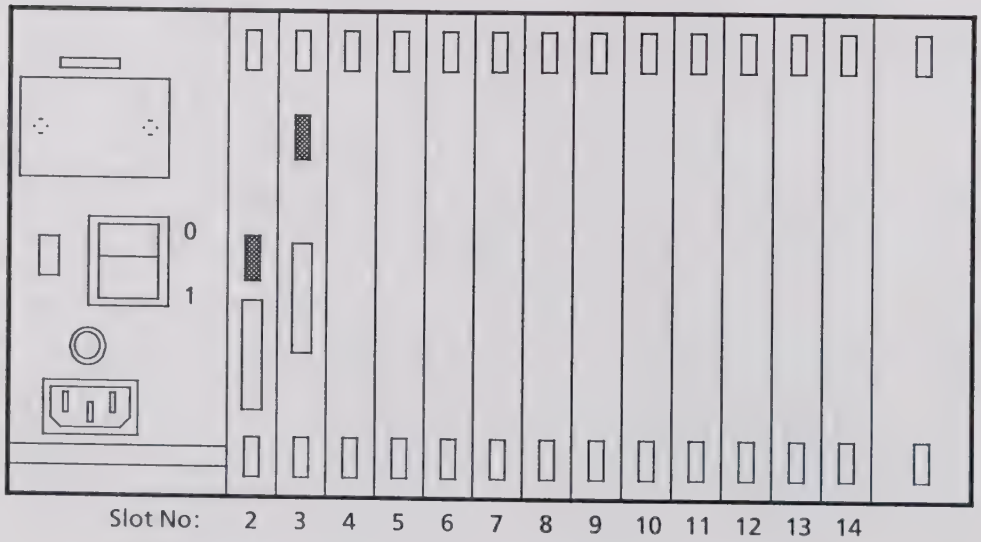

Fig 3.2 *Slot numbering of the SI 3535 Data Logger.*

4.1 BOARD HANDLING PRECAUTIONS

Some setup operations require the removal of cards from the unit. When handling the cards, take care that they are not damaged by static discharge or surface contamination. The precautions to take are detailed as follows.

4.1.1 Static Discharge

High static electricity voltages can be generated on the human body and the discharge of these voltages may cause permanent damage to certain sensitive devices. Cards containing static sensitive devices are identified by one of the following markings:

MOS – AVOID STATIC

Static damage may be avoided by wearing a ground strap when removing or replacing cards. Cards not in use should be stored in anti-static bags.

4.1.2 Surface Contamination

Take care, when handling cards, to hold them only by the edges, particularly avoiding the gold-plated edge connector fingers. This avoids chemical contamination of the card's surface by the salts present in the human skin. The consequence of chemical contamination is degradation of the unit's high humidity performance.

Care should also be taken to avoid contamination of the cards by dust, if stored outside the instrument. The use of anti-static bags avoids contaminination by dust, as well as protecting the cards from static.

4.2 CONTROLLER REAR PANEL SWITCH SETTINGS

Before operating the SI 3535 Data Logger from the front panel you may need to set some of the controller functions, using the switches on the controller rear panel. The location of these switches is shown in Fig 3.1. The switch functions are described in Table 3.3.

Table 3.3 Functions of the Controller Rear Panel Switches

Switch No.	Function
1, 2	Mode Select. Used for selecting output terminators and protocol in accordance with the type of peripheral device connected to the controller. Not applicable if no such peripheral device is used. (See the SI 3535 Reference Manual, Chap. 6, Sect. 2.4.)
3, 4	Language Select. See Section 3.
5	Test. For normal operation of the data logger this switch is set to OFF.
6	Boot. Set this switch to ON if you wish the data logger to boot up from a program in memory (or disk); otherwise, set the switch to OFF.
7	Modem. Set this switch to ON if a modem is connected to the controller; otherwise set the switch to OFF.
8	Battery Backup. Set this switch to ON if you wish to have the memory and clock battery sustained on power down; otherwise set the switch to OFF.

4.3 SECURING THE MODULES

When installed in the SI 3535 mainframe, the modules and input connector assembly must be secured to the top and bottom of the case with the screws provided. (See Fig 3.3.) This prevents access being gained, without the use of a tool, to hazardous voltages and also maintains good emc performance.

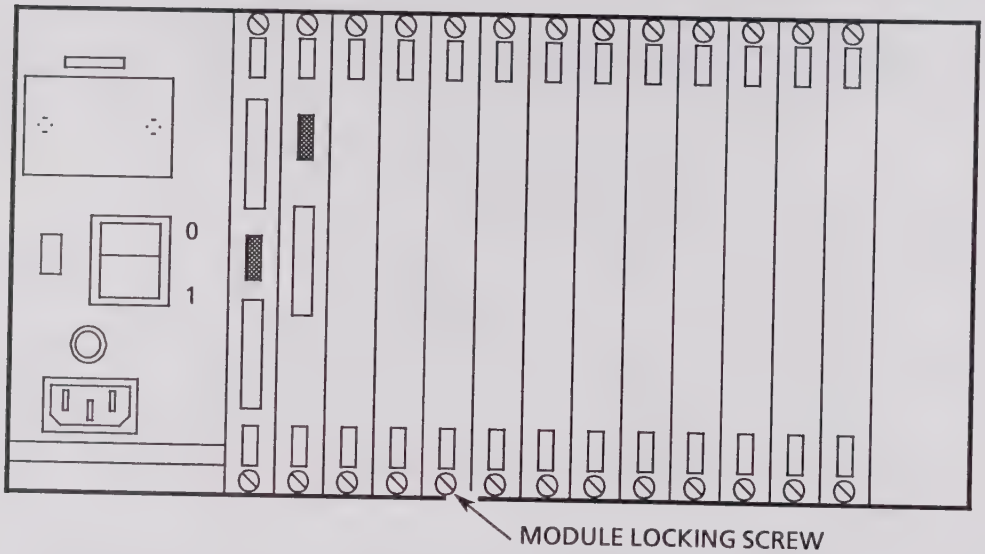

Fig 3.3 *SI 3535 rear view, showing the module locking screws.*

4.4 CONNECTION OF PERIPHERALS

Peripheral devices can be connected to the SI 3535 using the appropriate plugs/sockets provided on specific modules (mating connectors are supplied). The peripheral devices listed in Table 3.4 are typical, but other compatible devices may be equally suitable.

Full instructions for setting up and installing peripheral devices are given in the SI 3535 Reference Manual.

Table 3.4 Typical Peripheral Devices

MODULE	OUTLET	TYPICAL PERIPHERAL DEVICES
Controller	PL1	Any RS232C compatible device such as: (a) Printing terminal, e.g. DECwriter teletypes and printer-only terminals. Provides hard copy output to low speed printers, and permits control of logger from a terminal with keyboard. (b) Any suitable VDU. The VDU can be used to control the SI 3535, and to display data. (c) Computer, e.g. IBM computer with minimal interface. Hardware handshake not required, but single-character buffering in hardware is required, e.g. with an ACIA.
GPIB (IEEE 488)	PL1	Any GPIB compatible device such as a computer or calculator (talker/listener) or output peripherals (listener only).
Serial Interface	PL1 (port a) PL2 (port b)	Any RS422/232C compatible device (for both ports).

CAUTION: Take care, when handling modules, not to cause damage by static discharge. See Section 4.1 for handling precautions.

4.5 IMPORTANT NOTES ON UPDATING FROM ORION TO SCORPIO

Whilst every effort has been made to ensure compatibility between Orion and Scorpio, the following points should be noted.

Some Orion Modules can be used in Scorpio, whereas others can definitely ***not*** be used! This is discussed in Section 4.5.1 below.

Scorpio's command structure is designed to be as compatible as possible with that of Orion. This means that a control program written for Orion will, with little or no amendment, work also with Scorpio. The differences between Orion and Scorpio software are listed in Section 4.5.2 below. Note that the compatibility language between Orion and Scorpio is British English: if another language is set then the output format of dates, numbers and temperatures will change.

4.5.1 HARDWARE DIFFERENCES

Should you transfer Orion (SI3530) modules to Scorpio (SI3535), ***it is essential*** that only those SI3530 modules listed in Table 3.2 are used, and that these modules are inserted in the positions indicated by Table 3.2 and Fig 3.2.

This is particularly important in the case of the **SI 35301D** Transducer Energization Module, which is ***not compatible*** with Scorpio. Any attempt to use an SI 35301D module in Scorpio will damage both the logger and the energization module.

The Cartridge control card (from SI3530A or SI3530D) or the Disk control card (from SI3531D or SI3531G) are ***not required*** in the Scorpio (SI3535) and must not be fitted. Any attempt to fit these cards into the SI3535 may damage both the logger and the cards.

Connecting all Lows and Highs together is ***not possible*** when using a 35353C connector.

Note also that the transducer energisation voltage, available on pin 11, plug PL2, on the counter/timer option, is 24V in Scorpio (was 19V in Orion).

4.5.2 SOFTWARE DIFFERENCES

1. It is possible that some multi-statement lines of BASIC, which were accepted by Orion, may generate the "LINE TOO LONG" error in Scorpio. If this is the case then the single line should be split into two. The same is true for some WRITE and PRINT statements.

2. Since the size of the program database is greater in Scorpio it is possible to fit only four MS-DOS programs on a disk, or three HP-LIF programs.

3. The INitialise MEmory command in Scorpio causes control to be returned to the front panel device, whereas in Orion it doesn't.

4. Any timing loops used in the BASIC programming of Orion may have to be retimed for the faster processor of Scorpio.

5. Associated with the increased processing speed of Scorpio, any instruction that produces a pulse on a digital output line (by using the BASIC command SET twice in quick succession) should have delay instructions added. This ensures that the output line has time to change. For example, the original Orion command

   1023 SET 24 TO 1 : SET 24 TO 0

   should now be 1023 SET 24 TO 1 : FOR A = 0 TO 99 : SET 24 TO 0.

6. The default value for task scan intervals is now 0.1 seconds (was zero seconds in Orion).

7. On the SI 3535F and SI 3535G loggers the local terminal interface of the front panel is now dedicated for use with a DEC VT 220 compatible terminal (or terminal emulator) which provides control for the menu system used in the SI 3535D display.

8. In Scorpio, inappropriate channel setups result in an error message. This means that it is not possible, for example, to set up a non-existent channel or to set up an analog channel when a digital card is fitted, which was possible in Orion.

5 INSTALLING A VT220 AS A FRONT PANEL EMULATOR

With the "blind" loggers, SI 3535F and G, you have the option of local control from a VT 220 terminal.

This section tells you how to connect the VT 220 to the logger and lists VT 220 settings you should make to allow the terminal and logger to communicate. Full installation details of the VT 220 itself are contained in the VT 220 Installation Guide (DEC publication). General operation of the VT 220 is described in the VT 220 Owner's Manual (DEC publication) whilst its operation as a front panel emulator is described in Chapter 5, Section 2.2 of the present manual.

To connect the VT 220 terminal to the logger, simply plug the cable from its "host/port" connector into the MONITOR INTERFACE connector on the logger front panel.

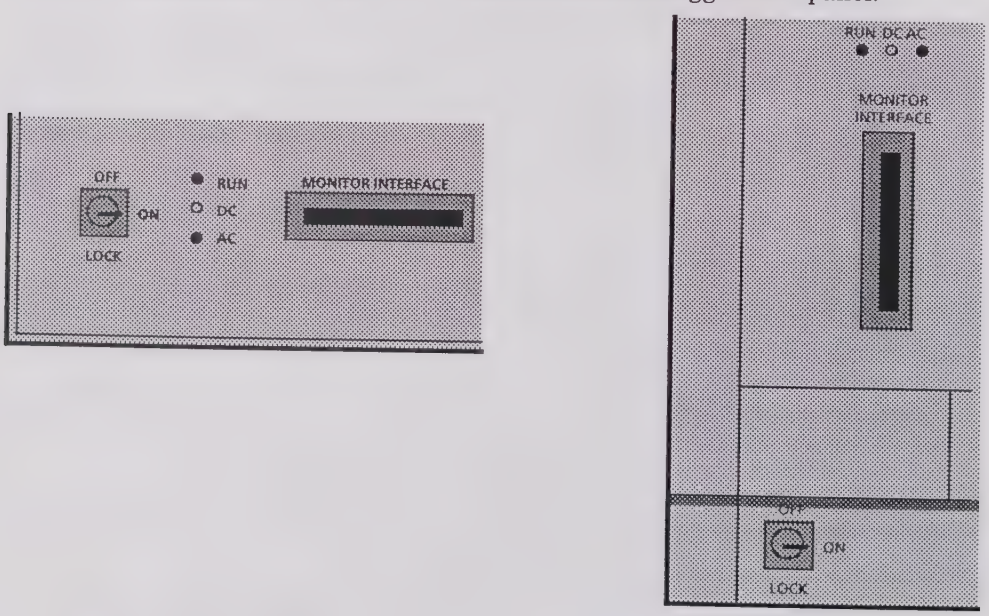

Fig 3.4 *The VT 220 connector on the SI 3535F and G data loggers.*

The VT 220 setups that ensure successful communication with the logger are:

- 80 columns,
- 19.2k baud for Receive and Transmit,
- XOFF at 64,
- 8 bits, no parity, 1 stop bit, no local echo,
- Printer setups in accordance with printer used.

These setups should be made as described in the VT 220 Owner's Manual.

6 CONNECTION OF EXPANSION UNITS

In all versions the SI 3535 main unit allows connection of up to two SI 3535 slave expansion units, providing a total capacity of 600 input channels. Each slave unit has 10 rear panel slots into which reed relay, solid-state, or high voltage solid-state selectors can be fitted, for the input of analog signals. These signals are measured and processed by the SI 3535 main unit in the same way as signals that are input directly.

6.1 SLAVE EXPANSION UNIT

Details for installing a SI 3535D slave unit (Fig 3.5) are given below; cables suitable for interconnection to the SI 3535 main unit are provided with the slave unit.

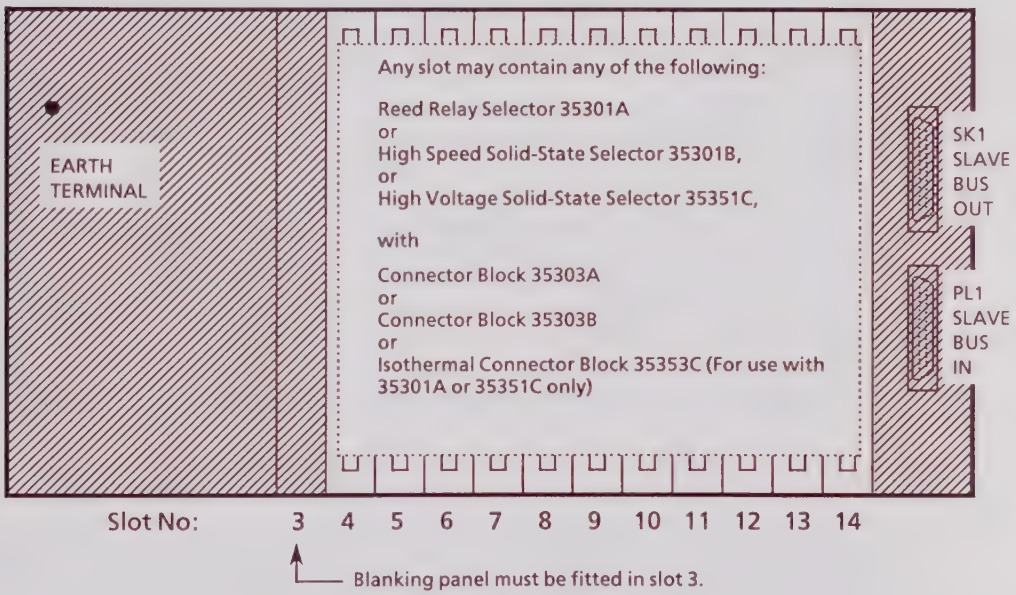
Any slot may contain any of the following:
Reed Relay Selector 35301A
or
High Speed Solid-State Selector 35301B,
or
High Voltage Solid-State Selector 35351C,
with
Connector Block 35303A
or
Connector Block 35303B
or
Isothermal Connector Block 35353C (For use with 35301A or 35351C only)
EARTH TERMINAL
SK1 SLAVE BUS OUT
PL1 SLAVE BUS IN
Slot No: 3 4 5 6 7 8 9 10 11 12 13 14
Blanking panel must be fitted in slot 3.

Fig 3.5 *Rear view of slave expansion unit.*

6.1.1 Equipment Required

(a) Controller Module,
(b) Transducer Energization Module (may already be fitted in Main Unit),
(c) Interconnecting cable (one per Slave Unit required).

6.1.2 Installation Procedure

WARNING:

1. The power switch on the Main Unit must be set to OFF before disconnecting or re-connecting the interconnection cables, or before any module is removed or replaced.

2. Any inputs that are connected to either the main unit or the slave unit which are carrying voltages in excess of ±30 V must be disconnected.

3. Before the Controller Module is removed or replaced, the front-panel keyswitch must be set to OFF.

1. Set the power switch on the SI 3535 Power Supply rear panel to OFF.

2. If a Transducer Energization Module (SI 35351D) is already fitted to the main unit, remove the module and connect the Analog Bus Links such that each solder pad is bridged (Fig 3.6). Refit the module into slot 15 of the main unit. If the module was not already fitted, connect the Analog Bus Links to a new Transducer Energization Module, as previously described, and fit the module into slot 14 of the main unit.

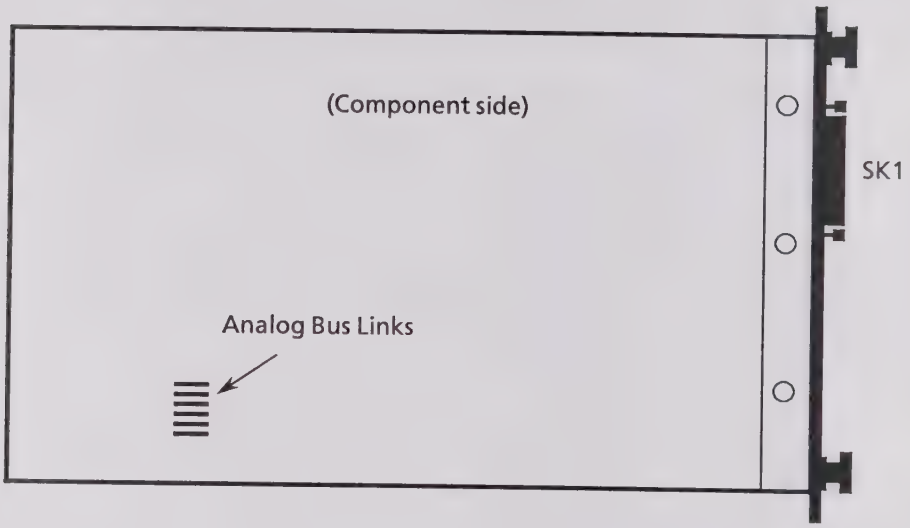

Fig 3.6 *Transducer energisation module — analog bus links.*

3. Fit the Reed Relay Selectors (SI 35301A) and/or Solid State Selectors (SI 35301B) and HVSS Scanner Module (SI 35351C) as required into slots 4 to 13 of the slave unit.

Note: Only analog inputs can be connected to the slave unit. Digital inputs can not be connected, and the following modules must not be fitted to a slave unit:

SI 35302A	Event-Status Input Module.
SI 35302B	Digital Input-Output Module.
SI 35301E	Analog Output Module.
SI 35302C	Counter Timer.
SI 35351D	Transducer Energisation Module.
SI 35351F	Transient Capture Module.

4. Position the main unit and slave(s) at the required location; the slave(s) units should be stacked on top of the main unit.

5. Using the interconnecting cable(s) supplied (35300227A), connect the main unit to the slave(s) as described in (a) and (b) below and as shown in Fig 3.7.

   (a) When using one slave, connect SK1 on the TEM of the main unit to PL1 (Slave Bus In) on the first slave.

   (b) When using two slaves, connect the first slave as above, then SK1 (Slave Bus Out) on the first slave to PL1 (Slave Bus In) on the second slave.

6. Connect the measurement inputs to the main unit and slave unit (2).

> **Note:** The main unit contains channels 001 to 200, the first slave unit contains channels 201 to 400, and the second slave unit (if fitted) contains channels 401 to 600.

7. Switch-on the SI 3535 main unit at the rear panel; the system is now ready for use.

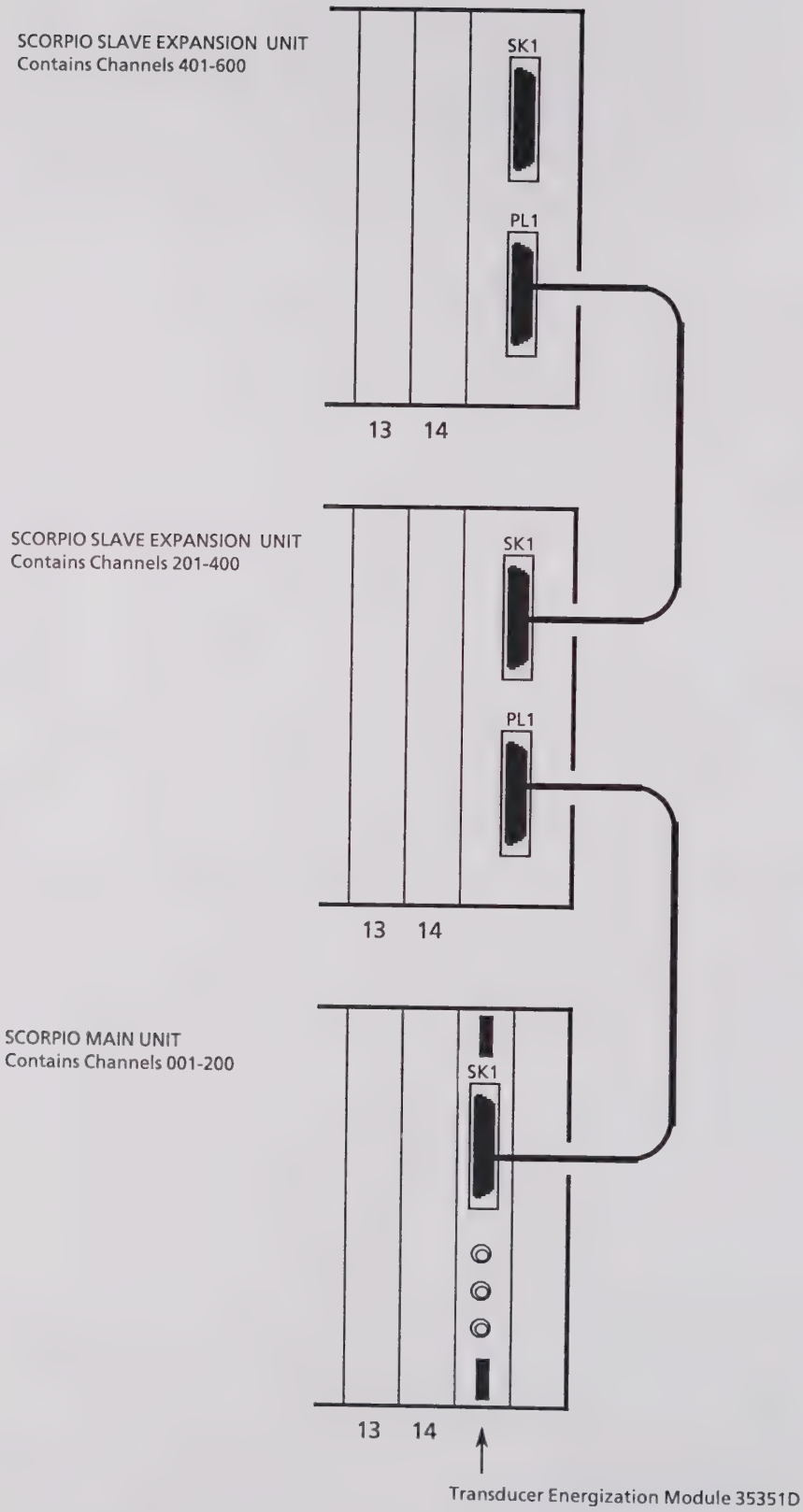

Fig 3.7 *Interconnections for SI 3535 main and slave units.*

7 MOUNTING OPTIONS

The SI 3535 can be used as a stand-alone desk-top device or, alternatively, mounted in a standard 19 inch rack. It is important that adequate ventilation is provided for the unit when it is fitted into a rack.

> **CAUTION** : The Scorpio is designed so that airflow is from the bottom to the top of the instrument. Any forced cooling provided by the rack should complement this. The logger should therefore be mounted below other equipment which dissipate significant power. The recommended spacing between the logger and other equipment in the rack is 25mm (20mm minimum).

The following two types of mounting kit are available:

(a) Rack mounting brackets, which are provided in the standard accessories kit. These are used with additional support brackets (to be supplied by the user) at the rear of the SI 3535.

(b) Telescopic slide mounting kit (SI 35305D) which is available as an optional accessory. This kit is suitable for racks with a depth of 30 inches, and allows the SI 3535 to be easily slid in and out of the rack.

7.1 STANDARD ACCESSORIES KIT

To use this method of rack mounting, proceed as follows:

1. Remove the finisher (Fig 3.8) on both sides of the SI 3535. Keep the retaining screws to fit the rack mounting brackets.

2. Remove the feet and tilt bar from the underside of the SI 3535 main unit. (**WARNING**: If at any time the feet or tilt bar are refitted the same screws must be used.)

3. Fit the rack mounting brackets (Fig 3.10) in place of the finishers, using the retaining screws. (The brackets are normally fitted with the flange nearest the front of the unit).

4. Check that there is adequate support in the rack for supporting the rear of the SI 3535 unit. (**WARNING**: The rack mounting brackets are for retaining purposes only, they must not be used to support the entire weight of the unit.)

5. Fit the SI 3535 unit into the rack and secure the brackets to the rack.

7.2 TELESCOPIC SLIDE MOUNTING KIT

To use this method of rack mounting, proceed as follows:

1. Remove the finisher on both sides of the SI 3535 (Fig 3.8). Each finisher is retained with two screws, keep these for fitting the rack mounting brackets.

2. Remove the feet and tilt bar from the underside of the SI 3535 main unit. (**WARNING**: If at any time the feet or tilt bar are refitted the same screws must be used.)

3. Remove the handle trims (Fig 3.9) from both sides of the unit; use a penknife blade or similar tool and lever out each trim on its upper or lower edge. Remove both handles.

4. Fit the rack mounting brackets (Fig 3.10) in place of the finishers, using the retaining screws. The brackets may be fitted either way round, but are normally fitted with the flange nearest the front of the unit.

5. In place of the handles (removed in step 3) fit the rack bars from the Mounting Kit; use the four countersunk screws provided for each bar. (Fig 3.11)

6. Remove the innermost mounting kit slider (press spring to release). Fit one innermost slider to each rack bar using the four pan-head screws and washers provided for each slider; locate the slider such that it butts up against the rear edge of the rack mounting bracket.

7. Fit the remaining parts of the telescopic slider assembly to the rack.

8. Pull out the sliders from the rack. Lift up the SI 3535 main unit so that it is level with the sliders. Mate the sliders on the rack with the innermost sliders fitted on the unit. Ensure that the spring on each innermost slider locates in the lug on the moving slider.

9. Press the release springs on the static part of slider assembly in rack and push the SI 3535 into the rack. To secure, screw the brackets to the rack. (Fig 3.11)

WARNING: Ensure that the rack will not tip over when the SI 3535 is first mounted on its telescopic slides or subsequently slid out of the rack for servicing. The weight of a logger with all modules fitted is 28kg (62lbs) for an SI 3535D/G and 26kg (57lbs) for an SI 3535F. Considerable leverage is thus obtained when the slides are fully extended and this could easily cause the rack to tip over if it is not properly secured (e.g. bolted to the floor).

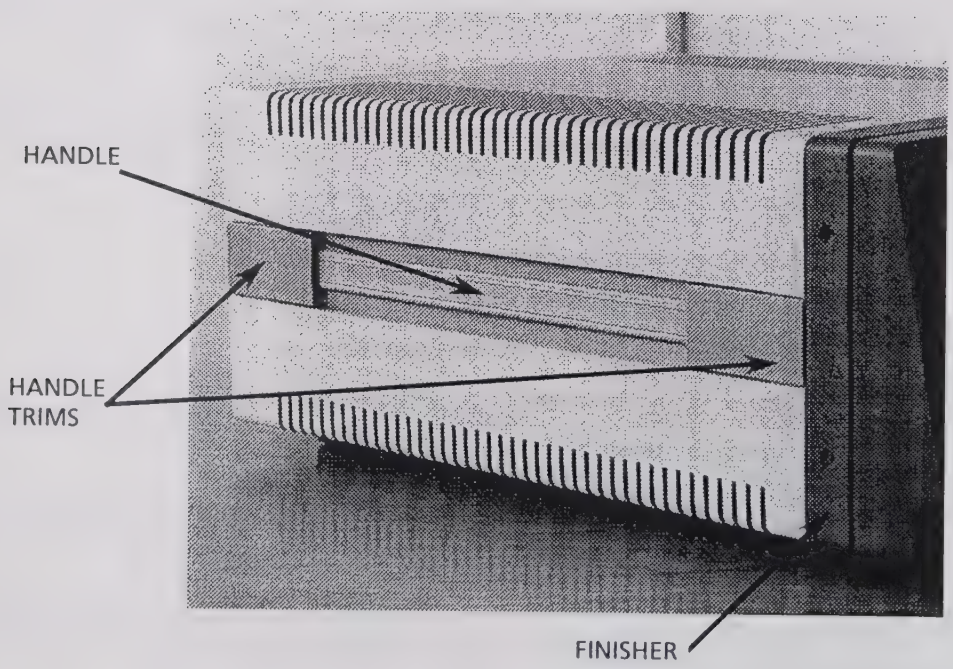

Fig 3.8 *SI 3535: location of handle, handle trim and finisher.*

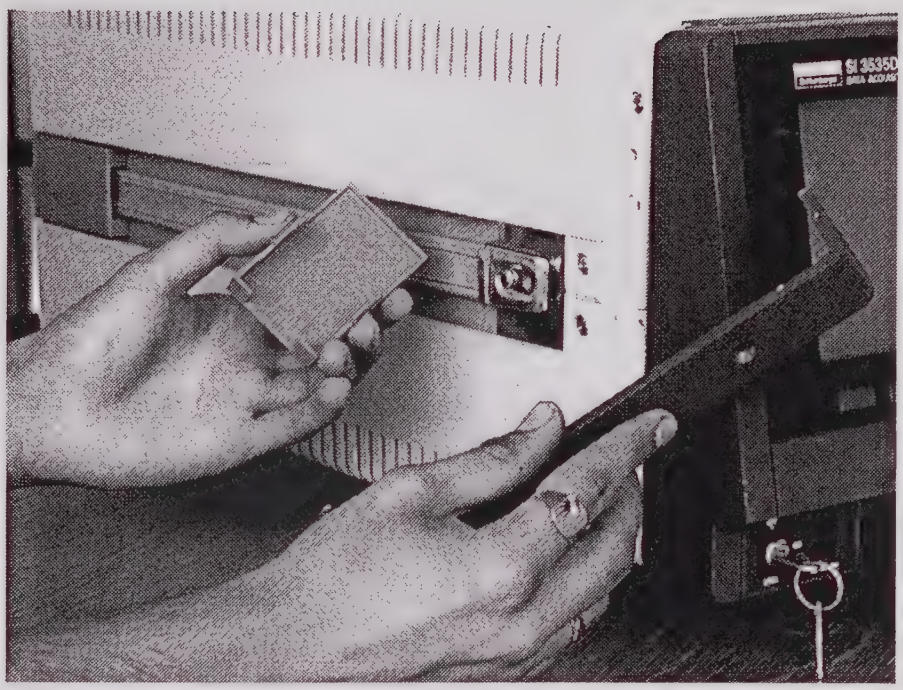

Fig 3.9 *SI 3535: finisher and handle trim removed.*

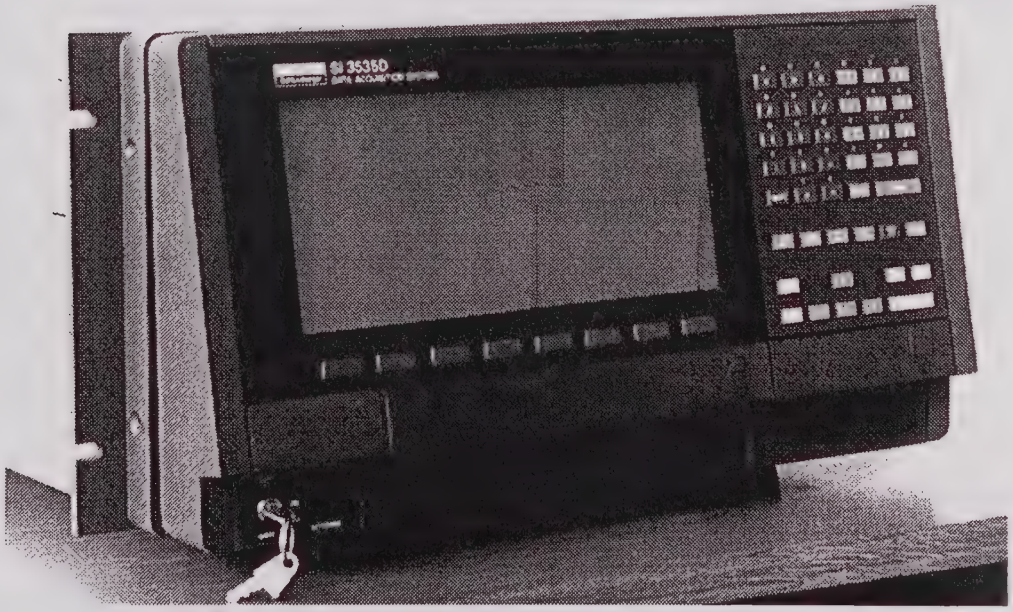

Fig 3.10 *SI 3535: mounting bracket fitted.*

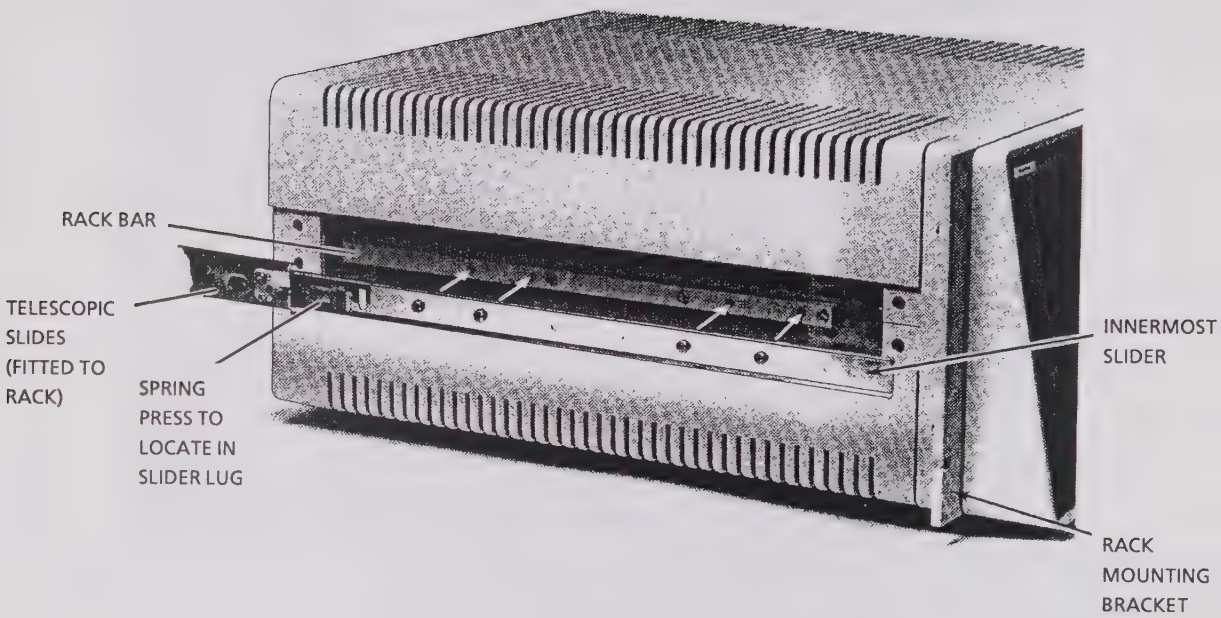

Fig 3.11 SI 3535: *fitting the rack mounting kit.*

8 PRINTER AND FLOPPY-DISK DRIVE

Details of the output from the printer and floppy-disk drive are given in Chapter 8. Setting-up of the printer and floppy-disk drive parameters is described in Chapter 5, Section 7.

8.1 CHANGING THE PAPER ROLL

To fit a new roll of thermal sensitive paper in the printer, proceed as follows:

1. If logger is on and set to RUN, set PAUSE/CONTINUE to PAUSE.
2. Pull down the hinged front cover on printer.
3. Lift up the printer securing lever (Fig 3.12) on either side of the printer assembly and use these levers to and pull the printer assembly out on its runners.

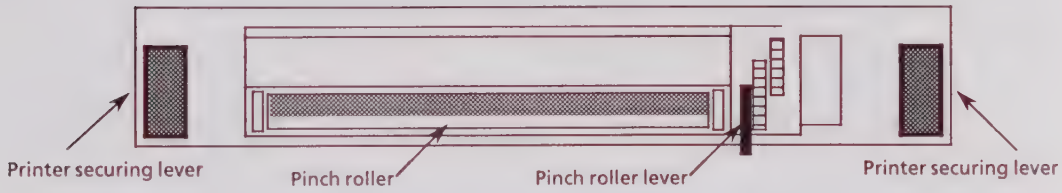

Fig 3.12 *Front view of printer mechanism.*

4. Lift out core of used paper-roll and spindle, and remove the spindle from the core.
5. Fit spindle in new roll. Feed paper through bottom aperture, with paper coming off front of roll. Drop roll and spindle into the roll compartment, locating the spindle in springs at either side. See Fig 3.13 (a).

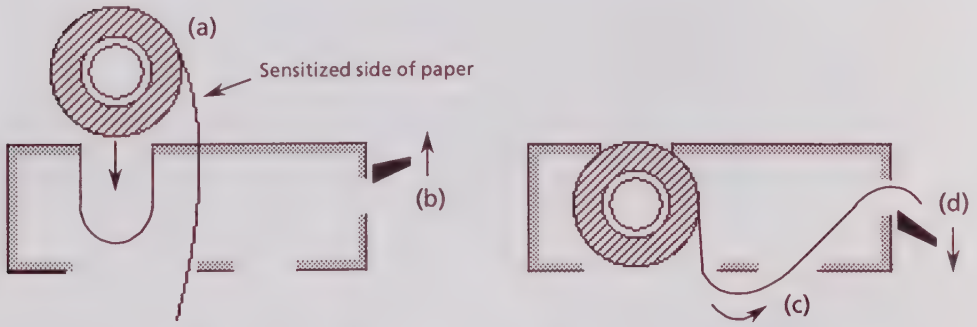

Fig 3.13 *Loading the printer paper-roll.*

6. Release the paper grip mechanism, by lifting up the pinch roller lever. See Fig 3.12 and Fig 3.13 (b).
7. Feed the paper up through the slot behind the rubber roller. Feed the paper past the roller until approximately 10cm emerges. See Fig 3.13 (c).
8. Line paper up equidistantly between the two white plastic guides at either end of the pinch roller, then lower the pinch roller lever.
9. Push printer back into the front panel and lower the two securing levers.
10. Feed paper through hinged front cover and swing cover back into position.

11. Set PAUSE/CONTINUE to CONTINUE.

Note: Use only a good quality thermal sensitive paper with the printer, as supplied by Solartron Instruments. Poor quality paper may adhere to the printer mechanism,

8.2 EJECTING AND INSERTING A DISK

To eject and re-insert a disk, proceed as follows:

1. Check the operating state of the SI 3535 Data Logger. It should be:

(a) in the HALT mode, or

(b) in the RUN mode, but set to PAUSE due to the disk being completely filled, or

(c) in the PAUSE state, selected manually with the the disk Unload facility. (Press the PAUSE key, wait for the message "Ready for command", and then press the disk Unload key.)

2. Carefully pull down the hinged cover in front of the disk drive.

3. **Ensure that the red record indicator on the disk drive is not illuminated.** Then press the disk eject button (Fig 3.14) to eject the disk.

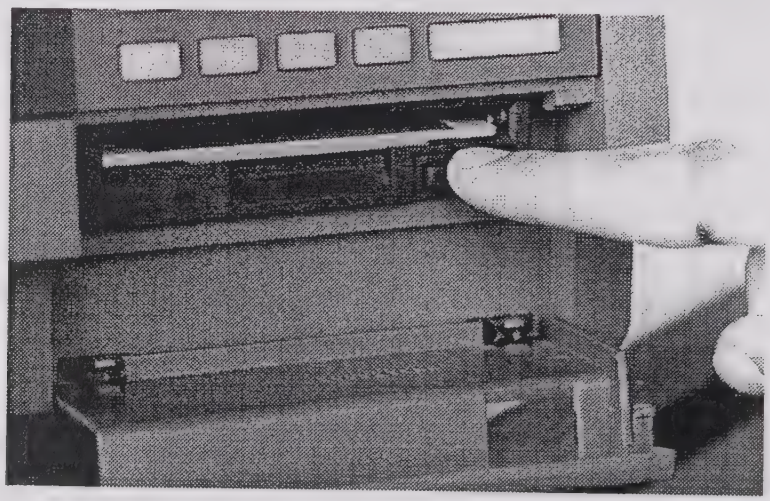

Fig 3.14 *Pressing the disk eject button.*

4. Before inserting a new disk check that the write-protect tab (Fig 3.15) on the disk is set as required. If the disk to be inserted is replacing a full disk (with the logger in the Pause state) then it should be ready-formatted.

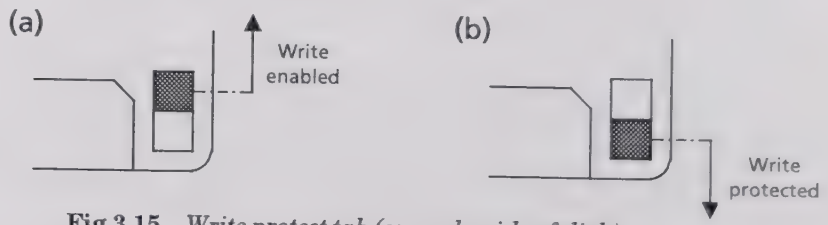

Fig 3.15 *Write protect tab (on underside of disk).*

5. To insert the disk, push it into the disk drive aperture until it clicks down into place. Then swing the disk drive front cover back into position.

Chapter 4
Using the SI 3535D

Section *Page*

1 **Introduction** 4.3

2 **Hardware definition** 4.3

3 **Preliminary Operations** 4.3

4 **Approach to Programming** 4.4
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5.1 Menu Structure 4.6
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5.3 Channel Definition 4.7
5.4 Monitor 4.8
5.5 Task Definition 4.8
5.6 Logger Setups 4.10
5.7 Running a Program 4.10
5.8 Using the Other Facilities 4.10

Figure

4.1 General order of logger setups 4.4

1 INTRODUCTION

This chapter demonstrates how to set up and use the SI 3535D data logger, using the front panel menus. A simple example of temperature measurement illustrates the general procedure. To help in the understanding of set-ups made from a computer, e.g. in the case of the SI 3535F or G loggers, the equivalent remote commands are given also.

This chapter aims to make you aware of the set-up and control facilities of the SI 3535D, F and G loggers and of the general set-up order, starting from initial conditions. Concise descriptions of all set-up and control facilities for SI 3535 loggers are given in Chapter 5.

2 HARDWARE DEFINITION

To configure the logger for the present example, you will need to connect some temperature sensors, via an appropriate scanner and input connector. The SI 3535 Series Data Loggers allow you to measure temperature using either a thermocouple or a platinum resistance thermometer (PRT*). (Guidance on which of these best suits your purpose is given in Chapter 2, Section 3.5.) The installation details for thermocouples and PRTs are given in Chapter 9 of this manual.

*Also known as a resistance thermometer device (RTD) or a PT 100.

For the purpose of the present example it is assumed that five PRTs and five thermocouples are connected to the logger, through an analog input scanner in Slot 4 of the mainframe. The scanner can be any of the following: SI 35351G or H; SI 35301J, K or L. The PRTs are connected to channels 1, 3, 5, 7, and 9, whilst the thermocouples are connected to channels 11 through 15. (Note that each PRT is actually connected through two channels, e.g. 1 & 2, 3 & 4, etc, but the two channels are considered as one and are addressed with the odd channel number.)

To provide an energization current for the PRTs an SI 35351D Energization Module must be fitted in Slot 14 of the logger mainframe. The value of this current is set automatically to 1mA.

3 PRELIMINARY OPERATIONS

1. Ensure that the logger is correctly installed, as described in Chapters 3 and 9, and that any associated equipment is correctly installed also.

2. Set the keyswitch on the logger front panel to "ON".

3. Should the logger power up in the RUN state (BOOT facility "ON") press the RUN/HALT hard key to select the "Halt" state.

4. The examples given in this chapter assume that the logger is in the initialized state. If it is not, enter the remote command IN ME. (**NOTE:** Before doing this it is wise to check if the present setups are still required and, if so, to save them on disk. See Chapter 5, Section 8.3.) Press ENTER and check for the "Ready for command" prompt. Then enter the command IN ME from the front panel keypad, by pressing the following keys:

The logger is now ready to set up. Proceed as shown in Sections 4 and 5.

4 APPROACH TO SETTING UP

The facilities of the SI 3535D Data Logger may be considered under five main headings, as shown in Fig 4.1. The arrows in Fig 4.1 indicate the general order in which the facilities should be set up, starting from initial conditions. The recommended setup sequence is described below.

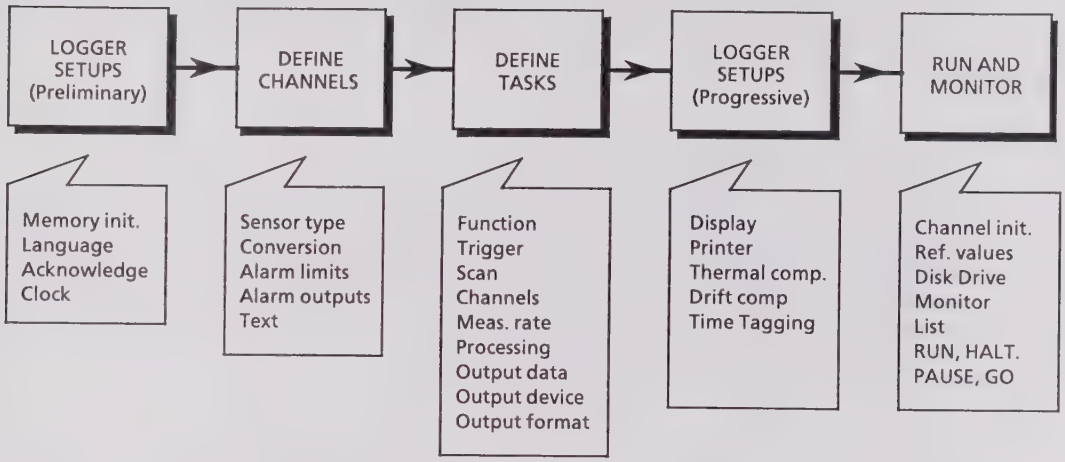


Fig 4.1 *General order of logger setups.*

4.1 Setup Sequence

Preliminary logger setups are those which affect the overall operating conditions of the logger, and should therefore be entered first. The facilities involved, e.g. memory initialization and language, are normally of occasional use.

Next comes the definition of the various input/output channels. Here the emphasis is on logger input, and items such as sensor type signal conversion and alarm limits are entered. An input "channel" carries a single stream of information, such as an analog signal from a thermocouple or strain gage, and the channel definition tells the logger how to interpret this information. Where several channels are dealing with the same type of signal, they can be covered by the same definition. Output channels may be used to take action in accordance with input alarm states: the programming for digital outputs is covered by the input channel definition, but for analog outputs further entries must be made through a Voltage or Current output menu (see Chap. 5, Sect. 4.5). Note that the form of the Channel menu depends on the type of channel being set up (e.g. analog, digital, etc.).

A task definition tells the logger which channels to measure, when to measure them, what processing to apply (if any) which results to log and where to log them. The channels specified for a task need not be of the same type, although, in practise, they often are. Up to eight tasks may be programmed, Task 1 having the lowest priority and Task 8 the highest. At the simplest level, several tasks may be programmed to run in sequence, each task scanning inputs of a particular type. However, it is possible to program several tasks to run concurrently, each task being cross-triggered by the alarm state of another (see Chap 5, Sect. 5.3.2.7).

Progressive logger setups are for the more regularly updated facilities related to general logger operation. They cover items such as the format of displayed and printed data, thermal and drift compensation, and the time tagging of results.

The Run and Monitor facilities are those that are frequently used when running your logging programs. These include the commands RUN, HALT and PAUSE, and the facilities for strain gage initialization and reference temperature definition.

Some examples of the way in which the logger facilities are set up, locally and remotely, are given in the next section.

5 SETUP EXAMPLES

This section demonstrates how to set up some of the logger facilities. In each example the aim is stated first: this is followed by the local control key pushes and then the equivalent remote control string. Follow the examples on your own logger, to get used to handling the controls. Some hints on using the menu structure are given below.

5.1 MENU STRUCTURE

The control menus allow you enter the logger control setups in a logical sequence. The general approach is as follows:

1. Press the hard key relating to the menu required. You have a choice of three:

   - PROGRAM — Selects the logger setup menus, i.e. those with which the channel and task details are entered. Everything entered under this key can be stored as a complete instrument setup on disk.
   - CONTROL — Allows you to use the peripheral logger facilities, such as setting the clock, listing setups, saving/loading programs, etc.
   - MONitor — Offers the choice of monitoring a specific channel, a task, or just the task headers, on a selected output device. This facility may be switched off if not required.

2. Each menu has a "tree" structure, as shown at the end of Chapter 5. Progress through the menu of your choice by making the appropriate entries. Whenever you reach the end of a "branch" the logger returns you to a point from which further entries may logically proceed. At any point you can exit from a menu by pressing an appropriate hard key (e.g. "RUN").

3. To leave an entry in its present state, press either the ENTER key or the down arrow key (↓). Similarly, to go back to a previous entry, press the up arrow key (↑).

5.2 PRELIMINARY LOGGER SETUPS

The preliminary setups for the present example are the date (e.g. 30.3 92: *dd-mm-yy*) and time (e.g. 15:39). Enter the time at the precise instant that the actual time corresponds with the keyed-in value.

KEY PRESSES

Ready for command: CONTROL MENU

Select required function: Clock

Enter date (dd-mm-yy): 3 0 - 0 3 - 9 2 ENTER

Enter time (hh:mm:ss): 1 5 : 3 9 : 0 0 ENTER

REMOTE COMMAND STRING: **IN DA** 30-03-92 **TI** 15:39:00

5.3 CHANNEL DEFINITION

In the present example the channel definition is in two parts, the first for the PRT channels (1, 3, 5, 7 and 9) and the second for the thermocouple channels (11 through 15). To keep things simple in the initial setup, only the sensor parameters are entered: the other channel "items" are left in the "no effect" state.

The entries for channels 1, 3, 5, 7 and 9 specify a PRT sensor and thermal compensation "on". It is assumed that the PRT is a 4-terminal type and that its resistance at 0°C is 100Ω. Energization of the PRT is set automatically to 1mA; input autoranging is used; and the input is linearized according to IEC Standard 751.

KEY PRESSES

	PROGRAM MENU
Select required item:	Channel
Enter channel numbers:	1 – 9 ENTER
Select item to be defined:	Sensor
Select measurement type:	PRT
Select thermal drift compensation:	On ENTER

REMOTE COMMAND STRING: **CH 1-9 SE 410**

The entries for channels 11 through 15 specify a thermocouple sensor, type N, with cold junction compensation referred to the ambient temperature (default setting).

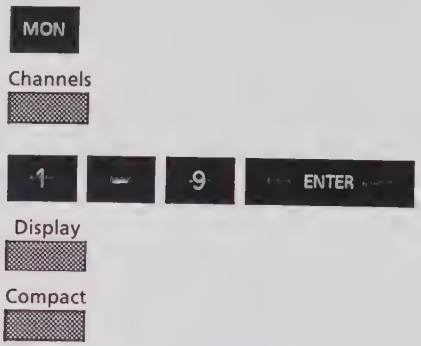
KEY PRESSES

Select required item:	Channel	
Enter channel numbers:	1 1 – 1 5 ENTER	
Select item to be defined:	Sensor	
Select measurement type:	Thermocpl	
Select thermocouple type:	N	
Select cold junction compensation:	↓	(Skip this entry, to use the default setting "Amb".)

REMOTE COMMAND STRING: **CH 11-15 SE 380**

5.4 MONITOR

Having set the channels you can give them a quick check by displaying some results measured with the MONITOR facility. For example, to check out Channels 1–9, press the following keys:



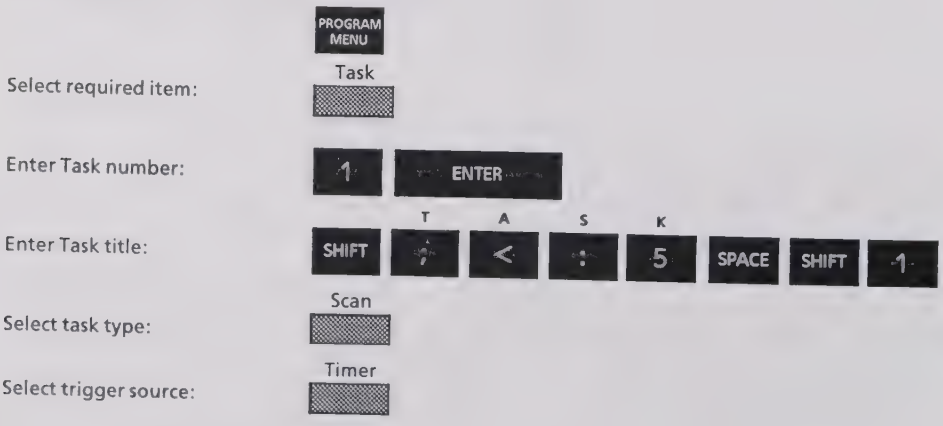
When you are satisfied with the results select MONitor Off.

5.5 TASK DEFINITION

The task defined in this example continuously scans the two channel groups defined above and displays the results on the logger screen. The full task definition is:

Task No.	1.
Name	"TASK 1" (example).
Function	Scan.
Trigger source	Timer.
Trigger delay	0.0 sec. (default value).
Number of scans	* (=unlimited number).
Cont./fixed interval	Continuous scanning.
Channels to be scanned	1-9, 11-15.
Measurement rate	10 measurements/sec.
End-of-scan processing	None (default setting).
Data to be logged	All results.
Task header	Always output.
Output device	Display.
Output format	Compact.
Tasks triggered on alarm	None (default setting).
Tasks aborted on alarm	None (default setting).

KEY PRESSES



Continued on next page.

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Enter delay to start dd-hh:mm:ss.t: [↓]

Enter number of scans (* = unlimited): [*] [ENTER]

Select continuous or fixed interval scan: Continuous

Enter channels to be scanned: [1] [–] [9] [,] [1] [1] [–] [1] [5] [ENTER]

Select measurement rate: 10/s

Select end-of-scan processing: [↓]

Select data to be logged: All

Select when to output task header: Always

Select output device: Display

Select format required: Compact

Enter tasks triggered on alarm: [↓]

Enter tasks aborted on alarm: [↓]

REMOTE COMMAND STRING:

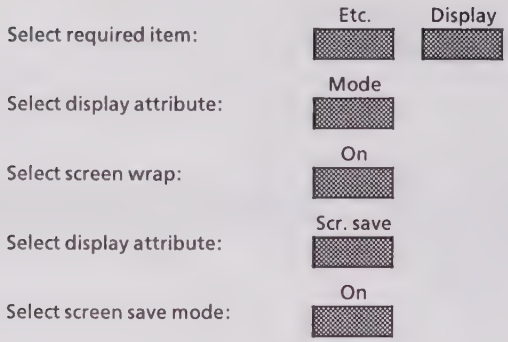
TA1 TI\TASK 1\ OP ME TR TI CO* CH1-9,11-15 AT F LO EV MA EV FO CO TO DI

To clarify the meaning of individual items in this string it may be broken down as follows:

TAsk 1	Assign the definition to task number 1.
TItle \TASK 1	The task title is "TASK 1".
OPeration MEasure	Measure the inputs (=Scan task).
TRigger TImer	Task triggered by timer (default delay=0.0sec.).
CO*	The number of scans is unlimited.
CH1-9,11-15 AT F	Scan channels 1–9 and 11–15 at 10 channels per second (integration time of 80ms).
LOg EVerything	Log all results.
MArk EVerything	Always output headers.
FOrmat COmpact TO DIsplay ...	Output the results, in compact format, to the display.

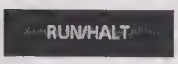
5.6 LOGGER SETUPS

As an example of a logger setup, select the display "wrap" mode and the "screen save" facility:

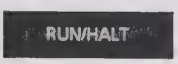


REMOTE COMMAND STRING: **IN DI WR ON SS ON**

5.7 RUNNING A PROGRAM



The program in the present example consists simply of Task 1, since that is the only task so far defined. To run the program, press the RUN/HALT key. Temperature measurements from channels 1–5 and 7–15 should now appear on the logger screen.



To halt the program, press the RUN/HALT key again.

REMOTE COMMANDS: **RU**n and **HA**lt

5.8 USING THE OTHER FACILITIES

Having set up and run the simple program above, try out some of the other logger facilities. For example, List, which is useful for printing or displaying a list of setups prior to reprogramming the logger. Also, try saving the present program to disk; then intialize the logger memory and load the program back again.

Before trying each facility, read the concise description in Chapter 5: then use the menus and the equivalent remote command strings to enter the various setups. A useful exercise is to modify the settings of the examples above and to check out the result. Don't worry about making a mistake: the logger will always let you know, with an appropriate error message! (Error messages are explained in the SI 3535 Reference Manual.)

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Logger Facilities

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1 INTRODUCTION

This chapter describes all the facilities of the SI 3535 Series data loggers.

Generally, the facilities appear under the names given to them in the front panel control menus, but reference to the equivalent remote command descriptions in the SI 3535 Reference Manual is given for each one. Where facilities are controllable only by remote command this is pointed out.

SI3535 Overview

The following flow diagrams, Fig 5.1 and 5.2, give an overview of the how the data flows within the SI3535 and how multi-tasking is achieved:

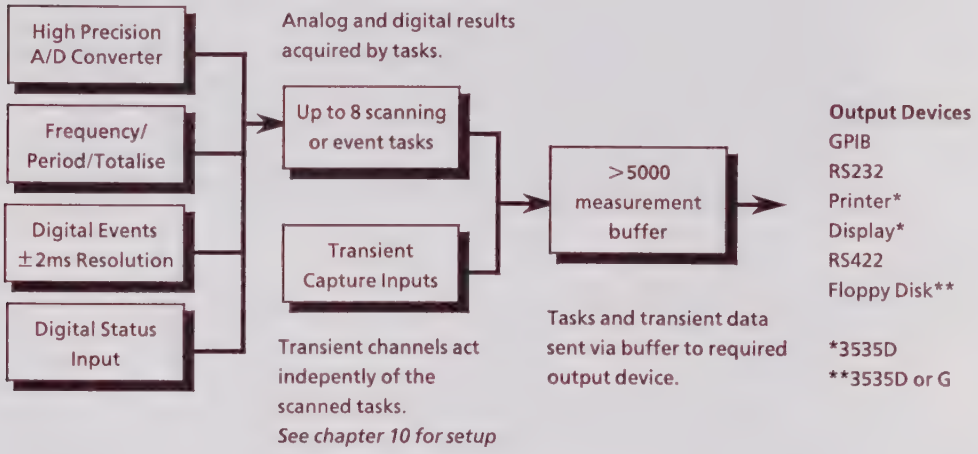


Fig 5.1a *SI 3535 Data Flow.*

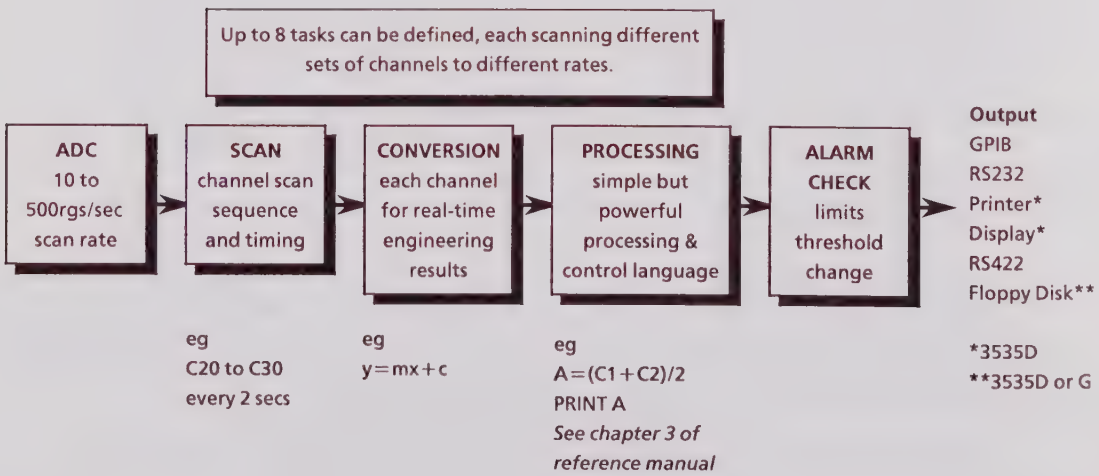


Fig 5.1b *SI 3535 Task Data Flow.*

Section 2 summarizes the various ways in which the various SI 3535 Series loggers may be controlled, locally or remotely. The remainder of the chapter is structured to reflect an initial setup, i.e. the facilities are described in the order in which an operator would set up the system, starting from the default settings (memory initialized state). See Figure 5.1c. This order is not mandatory, but is recommended for first-time users. Once the system is set up, subsequent adjustments may be made in virtually any order.

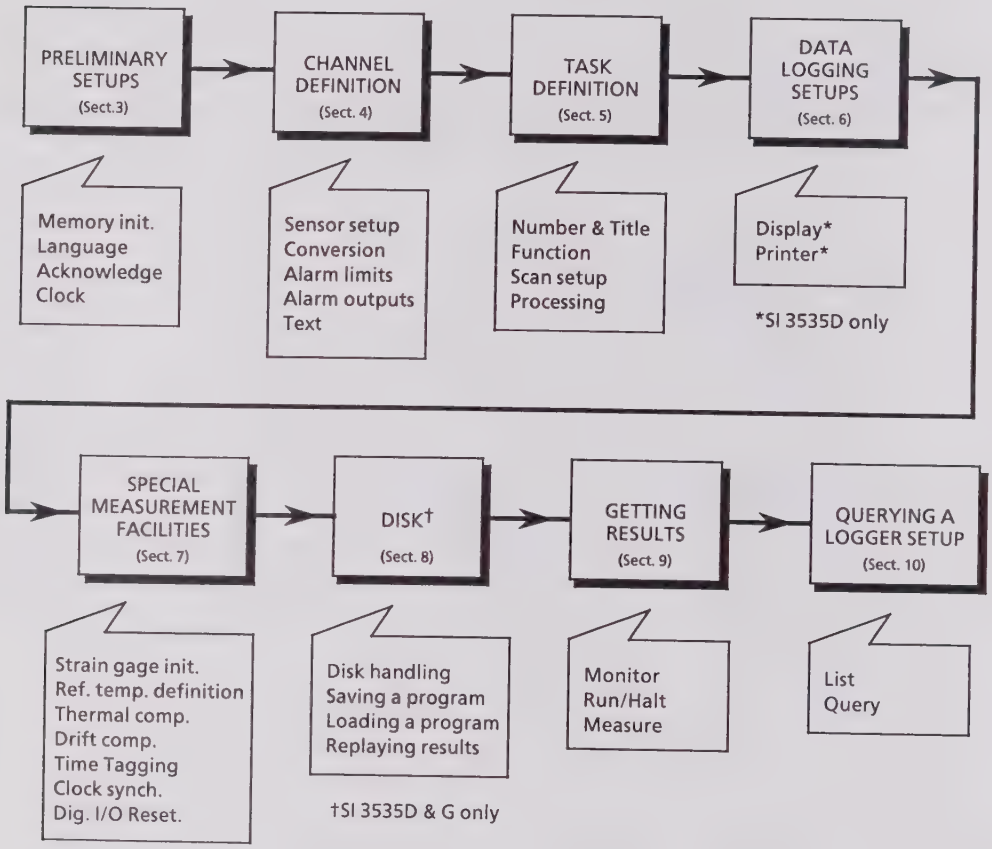


Fig 5.1c *SI 3535 setup sequence.*

2 SETUP CONTROL

All loggers in the SI 3535 Series can be set up under local or remote control. For local control, however, only the SI 3535D has the appropriate keys and display: the SI 3535 F and G models, being mainly intended for remote control, are "blind". To provide for local control of the F and G models a VT 220 video terminal can be plugged into the front panel to emulate the local controls and display.

A brief description of each method of control is given in Sections 2.1 through 2.3.

2.1 LOCAL CONTROL (SI 3535D)

The main features of the SI 3535D front panel are shown in Fig 5.2. Local control is exercised through control "menus", which are selected by clearly defined "hard" keys. In each menu, selections are made by means of the "soft" keys, whose functions are indicated by corresponding legends on the display.

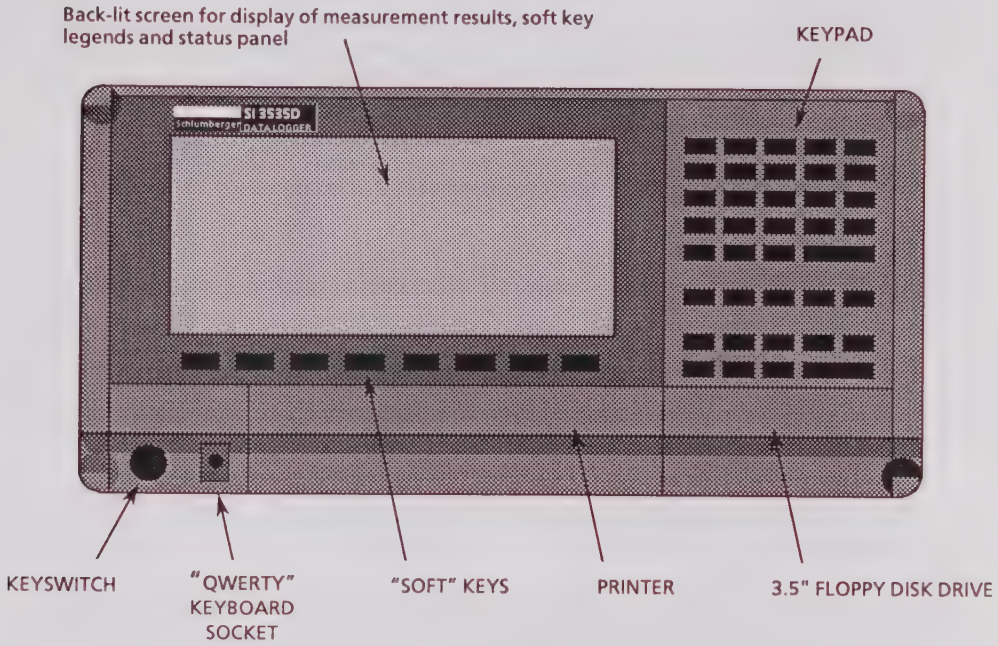


Fig 5.2 *Front panel features of the SI 3535D Data Logger.*

The alpha-numeric keys on the keypad, although mainly used for entering control variables via the control menus, can also be used to enter commands in remote form. (See the SI 3535 Reference Manual for details.) For operators who are more used to a "QWERTY" keyboard, this can be plugged into a front panel socket.

A back-lit liquid-crystal display provides all the measurement and control information required by the operator, in a clear and unambiguous form. Contrast control is available to allow for variations in viewing angle and for extremes of temperature.

The integral printer enables a hard copy to be made of selected measurement results, control setups or data previously recorded on the integral disk drive.

The integral disk drive (described in detail in Chapter 8) can be used to store measurement results or up to four control programs.

2.1.1 Keyswitch

The keyswitch controls the internal dc supplies of the logger, as follows:

OFF — DC supplies switched off. The logger is not operational, but its memory and clock are maintained by an internal battery.

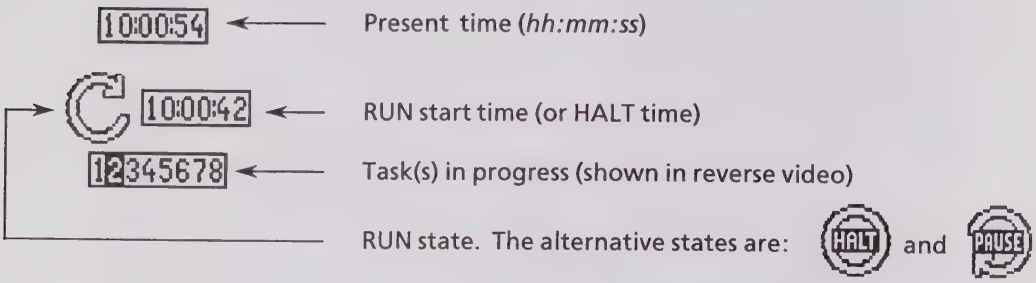
ON — The logger is powered up and fully operational.

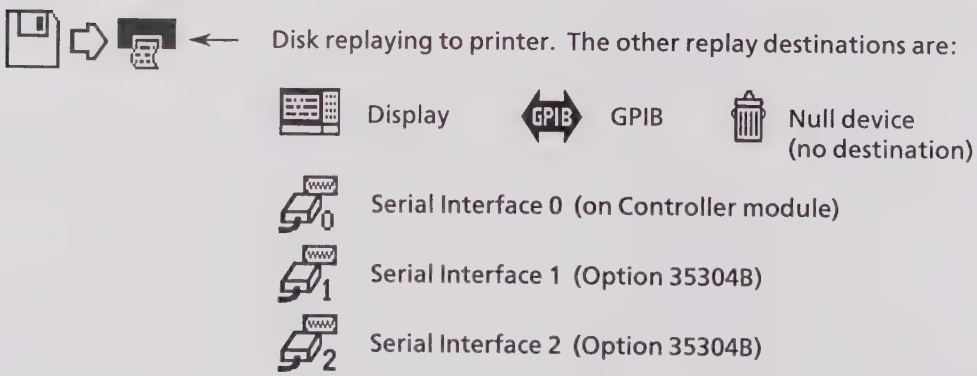
LOCK — The logger is powered up, but locked in its present mode of operation. The front panel controls may be used only to examine the control setups, not to change them.

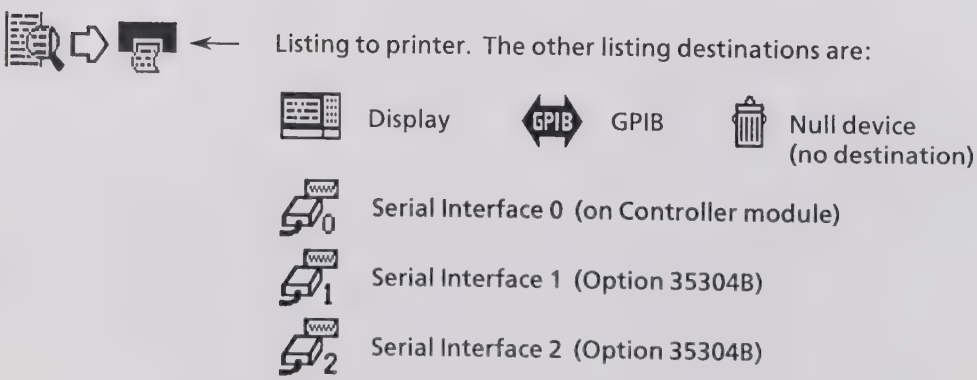
The internal dc supplies of the logger can derive their power either from the main ac supply (115/240Vrms) or from a dc supply (10V–32V dc). With both supplies connected the dc supply acts as a stand-by power source: should the ac supply fail, the dc supply takes over smoothly with no interruption in logger operation. The supply in use at any particular time is indicated by an appropriate icon on the display (see next section).

2.1.2 Status Icons

To indicate the control status of the SI 3535D various "icons" appear in the panel on the right of the screen. The meaning of each icon is shown below.







Continued on next page.

Monitoring to printer. The other monitor destinations are:

Display

GPIB

Null device
(no destination)

Serial Interface 0 (on Controller module)

Serial Interface 1 (Option 35304B)

Serial Interface 2 (Option 35304B)

AC power applied to logger.
Logger set for local control.

Logger set for remote control.

Logger set for remote control, with local lockout.

Logger set for local control and Keyswitch set to "Lockout".
Setups may be interrogated, but not altered.

DC power applied to logger.

2.2 LOCAL CONTROL WITH A VT220

The option of local control with a VT220 is available for the SI 3535F and the SI 3535G models. Each key that appears on the SI 3535D is represented by a key on the VT220 keyboard: the overall key arrangement is unavoidably different, but, where possible, the same key grouping is used (e.g. the function keys F1, F2, etc, become the menu "soft" keys). See the VT220 keyboard diagram in Fig 5.3.

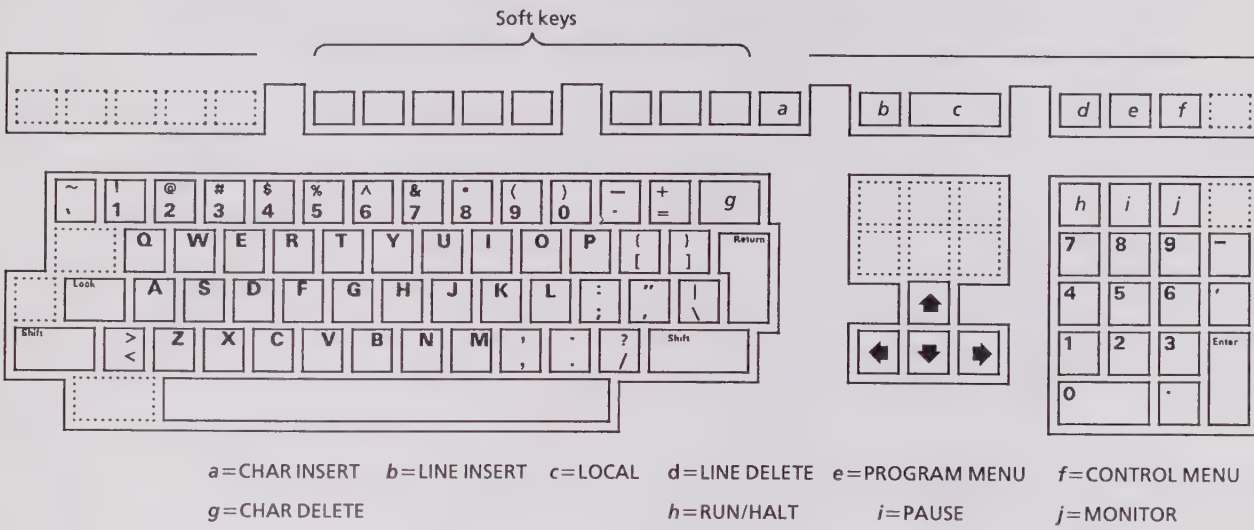


Fig 5.3 *Location of the SI 3535 control keys on the VT220 keyboard.*

Measurement results can be displayed on the VT220 screen in template or text form. (Bargraphs and Trend graphs are not available.) No logger status information can be displayed, although this may be accessed by a remote controller. An indication of the logger run state, HALT or RUN, and of the power supply status, AC or DC, is available on the LED display on the logger front panel.

Menus can be accessed by pressing the equivalent PROGRAM MENU or CONTROL MENU key, then using the softkeys in accordance with the legends displayed on the VT220 screen.

2.3 REMOTE CONTROL

Remote control is managed by coded commands that are sent by a remote controller to any of the logger's control interfaces, e.g. GPIB (IEEE 488) or RS232. Measurement data and status information is sent back to the controller by the same route. The remote control commands are described in the SI 3535 Reference Manual and reference to the appropriate sections in the reference manual are given in Sections 3 through 7 in the present chapter.

REMOTE CONTROL REFERENCES

For each logger facility described in this chapter, reference is made to the remote control details in the SI 3535 Reference Manual. Each reference appears, in brackets, at the end of its relevant section and is preceded by the "see also" symbol (▸▸).

e.g. (▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.1.)

Where a reference applies generally to a group of facilities it follows the text that introduces these.

3 PRELIMINARY SETUPS

The preliminary setups allow you to start setting up the logger from a known state. This is particularly important if the logger has previously been used for an application unrelated to the intended one.

3.1 MEMORY INITIALIZATION

Information in that part of the logger memory accessible to the user can be erased with the remote command IN ME. This command deletes any stored measurement results and user-defined programs, and sets all the control parameters to the default state.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.1.)

Before initializing memory it is a wise precaution to check if the present setups are still required and, if so, to ensure that these are saved on disk. (See Section 7.3.2, this chapter.)

3.2 LANGUAGE

The language used by the logger to output measurement results and control information can be selected from: British English, American English, French and German. This principally affects the front panel menus and the presentation of dates and numbers. (See Chap. 3, Sect. 3.1, this manual.)

The *default* language is determined by the setting of two switches on the rear panel of the controller module and an alternative language can be selected only with the remote command IN LA. (See Chap. 3, Sect. 3.1, this manual.)

(▸▸ SI 3535 Ref. Man, Chap 3, Sect. 2.1.)

3.3 ACKNOWLEDGE

The Acknowledge facility is intended for use with remote control. It ensures that a response is given to the controlling device for every command given to the logger. Some commands, e.g. query commands, produce an automatic response: acknowledge is used with those that do not.

- A query command is acknowledged by the logger's reply.
- A bad command is acknowledged by an error message.
- A good command that does not beg a reply is acknowledged by "E 000"

The Acknowledge facility can be switched on or off with the remote command AC ON/OF. It affects only those commands that do not give an automatic response.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.2.)

3.4 CLOCK

It is important to set the correct date and time into the logger clock, so that the timing of tasks and measurement results can be accurately defined.

The clock can be set either from "Clock" entries in the CONTROL menu (Fig 5.15) or by the remote commands IN DA (date) and IN TI (time).

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.1.)

4 CHANNEL DEFINITION

Before any measurements can be made, each channel to be used must be defined under "Channel" in the PROGRAM menu (see Fig 5.12a-e at end of chapter). The same setups can be entered remotely with the commands described in the SI 3535 Reference Manual, Chapter 3; individual references to this information are given in the sections below. The various aspects of channel definition are described in the order in which they appear in the PROGRAM menu.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.)

4.1 CHANNEL ASSIGNMENT

The first entry in the Channel menu identifies the channel, or channel groups, to which the definition is to apply. A channel definition can be assigned to any of the following:

- A single channel, n.
- A group of channels, n–m.
- A series of single channels, n_1, n_2, n_3, etc, up to 18 channels.
- A series of channel groups, n_1–m_1, n_2–m_2, n_3–m_3, etc, up to six groups.
- Any mixture of the above, e.g. n_1, n_2–m_2, n_3, etc.

Note that a group of channels is not permitted to carry more than one type of input or to span missing channels. (**Note**: This does not apply to the channels "missed" when 6-pole channels are assigned the odd channel numbers.)

4.2 SENSOR

The "Sensor" setups indicate the way in which input signals are to be sensed on the assigned channel(s). The sensor menu depends on the type of input module used: Analog, Digital, Status-Event or Counter-Timer.

★★★ **A guide to choosing and using the sensor(s) best suited to your application is given in Chapter 2 of this manual.**

The setups to be made for each type of input are decribed in Sections 4.2.1 through 4.2.4 below.

4.2.1 Analog Inputs

Analog inputs are connected to the logger through one of the following modules:

- 35351G/H High-Voltage Solid-State Module.
- 35301J High-Speed Solid State Module.
- 35301K/L Reed-Relay Module.

For each of these modules the choice of input sensor is as shown in Table 5.1.

Table 5.1 Choice of Sensor for Analog Inputs

SENSOR	SETTINGS
Volts	DC or AC
Amps	DC or AC
Ohms	4 or 2-terminal measurement; 1mA, 100µA or user-defined energization current; Thermal compensation off/on.
Thermocouple	Thermocouple type: E, J, K, B, N, T, R, S. Cold junction compensation: Ambient, Ref 1, Ref 2, Ref 3, Ref 4, External 0°C.
PRT	Thermal compensation off/on.
Strain	Select bridge type: Full-bridge: Thermal compensation off/on; energization voltage=2V/10V; gage factor. Half-bridge: Thermal compensation off/on; energization current=8mA, 1mA or user-defined; gage factor. Quarter-bridge: Thermal compensation off/on; dummy=remote 120Ω or user defined X, Y, or Z; energization current=8mA, 1mA or user-defined; gage factor.
4-20mA	Select 4-20mA setting in CONVERSION menu, and define low and high input values. (See Section 4.3 in this chapter.)

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.1.)

4.2.2 Digital Inputs

Digital inputs are connected to the logger through the 35302B Digital Input-Output Module. The choice of input sensor for this module is shown in Table 5.2.

Table 5.2 Choice of Sensor for Digital Inputs

SENSOR	SETTINGS
Bit	Status bits. Enter the number of bits to be input (1–8).
BCD	External module* measurement mode (BCD) Enter number of decades to be input (1–5).
Inverted BCD	External module* measurement mode (inverted BCD). Enter number of decades to be input (1–5).
Binary	External module* measurement mode (binary). Enter number of 8-bit bytes to be read (1–3).

* The number of this module is included in the task definition.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.3.)

4.2.3 Status-Event Inputs

Status-Event inputs are connected to the logger through the 35302D Status-Event Module. The choice of input sensor for this module is shown in Table 5.3.

Table 5.3 Choice of Sensor for Status-Event Inputs

SENSOR	SETTINGS
Bit	Status bits. Enter the number of bits to be input (1–8).
BCD	Binary coded decimal inputs (8-4-2-1). Enter number of decades to be input (1-5).
Inverted BCD	Inverted logic binary coded decimal input (8-4-2-1). Enter number of decades to be input (1–5).
Event	Channels are monitored continuously for "events", i.e. an input transition. Select the transition of interest: Hi→Lo, Lo→Hi, or any transition.
Count	Input pulses are counted: the count is reset btween readings. Select the transition of interest: Hi→Lo, Lo→Hi, or any transition.
Total	Input pulses are counted: the count is cumulative (totalized). Select the transition of interest: Hi→Lo, Lo→Hi, or any transition.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.5.)

4.2.4 Counter-Timer Inputs

Counter-Timer inputs are connected to the logger through the 35302C Counter-Timer Module. The choice of input sensor for this module is shown in Table 5.4.

Table 5.4 Choice of Sensor for Counter-Timer Inputs

SENSOR	SETTINGS
Frequency	Select the external or internal gate. Select the gate width: external=600s max; internal= 0.1, 1, 10, or 100s.
Total	Gives the running total, or final total, of input pulses which occur whilst the gate is open.
Period	Gives the average period of the input signal. Select the number of periods to be averaged: 1, 10, 100, 1000, or10000.
Interval	Gives the time between two consecutive transitions.
Off	The counter-timer is switched off, but any parameters set remain in memory.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.6.)

4.3 CONVERSION

A conversion may be applied to the signal(s) input through the assigned channel(s). The conversion is specified by a conversion number (1–600) in the Channel definition menu. This number points to the actual conversion used, which is defined under "Conversion" in the PROGRAM menu (Fig 5.14). Table 5.5 lists the conversions available.

Defining conversions in this way allows a conversion to be defined just once, and used in several different channel definitions.

Table 5.5 Choice of Conversions for Value Inputs

CONVERSION	EFFECT ON RESULT
Scale	$y=mx+c$ Enter m and c, the scaling and offset values.
Reciprocal	$y=a \div x$ Enter a, and the units for y.
Polynomial	$y=ax^3+bx^2+cx+d$ Enter a, b, c, and d, and the units for y.
Root	$y=\sqrt{ax+b} \times c + d$ Enter a, b, c, and d, and the units for y.
4-20mA	Enter scaling values: l for a 4mA input and h for a 20mA input.
Off	Conversion is deselected, but the parameters are left in memory

"x" in all expressions is the measured value: "y" is the result of conversion.

Further details of conversions are given in Chapter 6, Section 2.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.4.)

4.4 ALARM

Various alarm conditions can be set up for the assigned channel(s). For all value inputs (whether analog or digital) the same alarm conditions are selectable, as listed in Table 5.6. For digital bit-pattern inputs, alarm match or mismatch patterns can be set up as summarized in Table 5.7.

For all alarms, any combination of the following actions can be taken:

- Output restricted to alarm results. (See Task Definition, Section 5.3.1.7.)
- Alarm text output with alarm results. (A text number is specified in the channel definition, under "Text", and the text to be used is entered under "Text" in the PROGRAM menu. See Section 4.6.)
- Associated digital output channel(s) asserted to control external equipment or to give remote indication of alarm. (The alarm output channels are defined under "Output" or "Alarm Out" in the channel definition. See Section 4.5.)
- Another task is triggered. (See Task definition, Section 5.3.1.11.)
- Another task is aborted. (See Task definition, Section 5.3.1.11.)

Table 5.6 Choice of Alarm Conditions for Value Inputs

ALARM TYPE	CONDITIONS APPLIED
Limits	Enter a high limit and a low limit. An alarm is given if the measured result is greater than the high limit or less than the low limit.
Upper Threshold	Define a "deadband" by entering a low limit and an upper threshold limit. An alarm is given by the first result above the upper threshold limit. Subsequent alarms are given only when a string of results has crossed the deadband in a positive direction.
Lower Threshold	Define a "deadband" by entering a high limit and a lower threshold limit. An alarm is given by the first result below the lower threshold limit. Subsequent alarms are given only when a string of results has crossed the deadband in a negative direction.
Change	Enter a change value. An alarm is give by the first result, whose value defines the change datum. Subsequent alarms are given when a result is outside the datum ± change levels. Each alarm result redefines the change datum.
Off	Alarm is deselected, but the parameters are left in memory

Table 5.7 Choice of Alarm Conditions for Bit Pattern Inputs

ALARM TYPE	CONDITIONS APPLIED
Match	Enter alarm pattern. Alarm is given when the input pattern is the same the alarm pattern.
Mismatch	Enter alarm pattern. Alarm is given when the input pattern is the different from the alarm pattern.
Off	Alarm is deselected, but the parameters are left in memory

Full details of alarms and their application are given in Chapter 6.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.1.)

4.5 OUTPUT

Two types of signal can be output in accordance with the performance of the assigned input channel(s). These are a High or Low Alarm output from an SI 35302B Digital Input-Output Module and/or a proportional analog output (for analog inputs) from an SI 35301E Analog Output Module. These signals are used to drive external equipment, such as control switches and indicators and, in the case of the analog output, plotters.

The way in which output channels are defined is described in Sections 4.5.1 and 4.5.2.

4.5.1 Digital Outputs

The digital alarm outputs are specified under "Output" in the input channel definition. Enter two channel numbers, one for the low alarm and one for the high alarm.

The high alarm output goes from "0" to "1" for an alarm in a positive direction, whilst the low alarm output does the same for an alarm in a negative direction. Details are given in Chapter 6.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.3.3.)

4.5.2 Analogue Outputs

The number of the analog output channel is specified under "Output" in the input channel definition. The parameters of the analog signal itself are specified in the output channel definition (Fig 5.12e).

Analog outputs are switch selectable for voltage or current. (See Chapter 9, Section 7.) The present mode of output is indicated in the bottom right hand corner of the front panel display (SI 3535D models).

In the output channel menu an analog output may be defined under one of two headings: "Value" or "Scale".

A Value output is normally used for setting up and test purposes. Enter a percentage value from 0% to 100% to obtain a fixed output in the range:

0V to 10V for a voltage output, or
4mA to 20mA for a current output.

A Scaled output permits the maximum output resolution over a particular range of interest and is particularly useful when results are being plotted. Enter two values to define the range of interest of the input signal, one for a 0% output (4mA or 0V) and one for a 100% output (20mA or 10V). The values entered relate to the numeric value of the measured results: the engineering units (e.g. μstrain, °C, etc.) are automatically assumed in accordance with the sensor definition.

A full description of analog outputs is given in Chapter 9, Section 7.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sects 2.3.1 and 2.3.2.)

4.6 TEXT

Under "Text" in the channel definition two text numbers are entered, one for normal text and one for alarm text. The actual text is entered, against the same numbers, under "Text" in the PROGRAM menu (Fig 5.15). This allows commonly used text to be entered just once and used in more than one channel definition.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sects 2.3.1, 2.3.3—2.3.6 and 2.5.)

5 TASK DEFINITION

Local control setups for task definition are entered under "Task" in the PROGRAM menu (Fig 5.13). The same setups can be entered remotely with the commands described in the SI 3535 Reference Manual, Chapter 3; individual references to this information are given in the sections below. The various aspects of task definition are described in the order in which they appear in the PROGRAM menu.

Up to eight logging tasks can be defined. These can run concurrently on a priority basis or can be cross-triggered, one with another, in accordance with alarms or task processing.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.6.)

5.1 TASK NUMBERING

Tasks are numbered from 1 to 8, with Task 1 having the lowest priority and Task 8 the highest. Thus Task 1 can be interrupted by Task 2; Task 2 can be interrupted by Task 3; and so on.

To ensure that lower priority tasks are not locked out, avoid using high priority tasks for continuous scanning. (This applies particularly to digital inputs.)

5.2 TASK TITLE

A task title of up to eighteen characters may be entered. This title is output with the task header, when this is enabled, and allows the results from each task to be identified. (See Chapter 7 "Output Formats".)

5.3 TASK FUNCTIONS

A Task function can be defined as a "Scan" or an "Event". An "Off" setting is also available for switching the task off, whilst retaining the setups in memory. The setups for Scans and Events are described in Sections 5.3.1 and 5.3.2 below.

5.3.1 Scan Task Setups

A Scan task deals with any type of input, analog or digital, that represents a measurable quantity or the status of external equipment. The setups are described below.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.6.1.)

5.3.1.1 *Trigger Source*

A scan task may be triggered from the Timer, the Clock, or another task. (The Timer and the Clock are derived from the logger's internal clock.) The logger must be in the RUN state for any of these triggers to act.

Under "Timer" a task start delay is entered. This delay can cover days, hours, minutes and seconds and starts from the time that the RUN command is given.

Under "Clock" the task start time is entered.

Under "Task" a start delay is entered. This delay starts from the time that the present task is triggered from another. This other task includes the number of the present task as a "Task to be triggered".

5.3.1.2 *Number of Scans*

A task can be set to make a finite number of scans, between 1 and 65535. On completion of the last scan the task waits for the next trigger.

Alternatively, an asterisk (*) denotes an unlimited number of scans. With this, scanning continues, in accordance with the task priority, until the logger is given a HALT command.

5.3.1.3 *Continuous/Fixed Interval Scanning*

In continuous scanning (Fig 5.4) the last result of one scan is output before the next scan is started. This limits the amount of input data acquired, in accordance with the speed of the output device, and ensures that the output data buffer of the logger is never completely filled. The actual measurement rate is unaffected by the speed of the output device, but the proportion of data input time to data output time is. In other words, the faster the output device the greater the amount of data acquired within a set period.

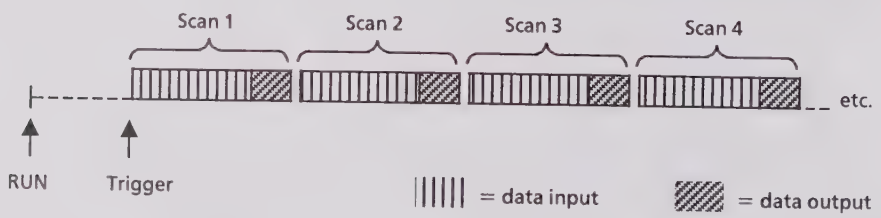


Fig 5.4 *Timing of continuous scanning.*

In interval scanning each successive scan is started a set interval after its predecessor. The interval specified can be greater or less than the total scan time, which allows interval scanning to be used in one of two ways. Specifying an interval greater than the scan time (Fig 5.5) provides for the periodic acquisition of slow changing data.

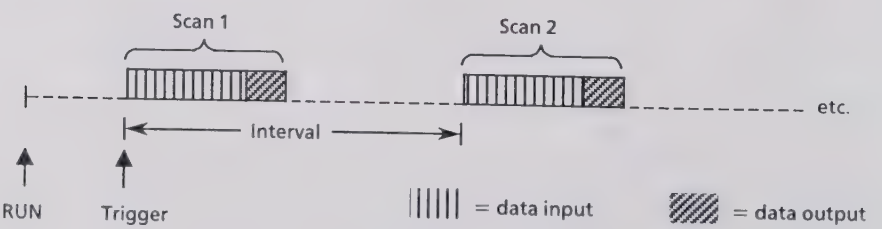


Fig 5.5 *Timing of long interval scanning.*

Alternatively, for the fast acquisition of rapidly changing data, the interval can be made to cover just the data input period (Fig 5.6). Data thus accumulates in the logger output buffer, to be output a few seconds later. However, the number of results acquired in this way can not exceed the buffer capacity of 5000 results: immediately the buffer is full, scanning stops.

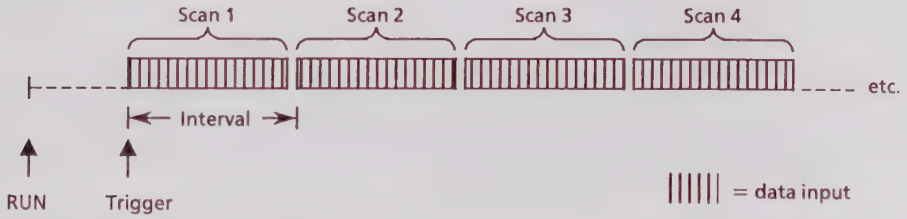


Fig 5.6 *Timing of short interval scanning.*

5.3.1.4 Channels to be Scanned

When entering the numbers of the channels to be scanned there are a few simple rules to remember:

- You can specify up to 18 individual channels, or up to six channel groups, or a mixture of individual channels and groups. When entering a mixture, remember that three single channels are equivalent to one group.

- When using Slave Expansion Units, you should group only those channels contained in the same unit. The channel numbering for the main and slave logger units is as follows: the main unit contains channels 001 through 200; the first slave unit contains channels 201 through 400; and the second slave unit contains channels 401 through 600. As an example, it is not permitted to specify the channel group 191-209 directly since it spans two units: instead, the same channels should be split into two groups and entered as "191-200,201,209".

- To scan any channel several times in succession, enter the channel number the number of times it is to be scanned, e.g. enter "24, 24, 24" to scan channel 24 three times. Do the same thing with channel groups, e.g. enter "1-5, 1-5" to scan channel group 1-5 twice.

- Enter channel numbers in the order in which the channels are to be scanned. For example, enter "2,4,6,8,10-19" to scan the specified channels in ascending order, or "19-10,8,6,4,2" to scan the same channels in descending order.

- For external module measurements, controlled through the SI 35302B Digital Input-Output Module, enter module numbers in place of channel numbers. See chapter 9, Section 5.4.

5.3.1.5 Measurement Rate

The choice of a measurement rate (channels/second) is applicable only to analog measurements. The chosen rate determines the measurement integration time, and is the *maximum rate* at which measurements can be taken, i.e. that obtainable with the SI 35301J High Speed Solid-State Scanner. The equivalent measurement rates obtained with other types of scanner are given in the SI 3535 Specification in Appendix A of the manual.

Choose a measurement rate just sufficient for the task in hand. Remember that a high measurement rate allows a large amount of date to be acquired, but at the expense of reduced noise rejection and measurement resolution.

Note that the rate at which measurement results are output is not necessarily the same as the measurement rate, particularly at the higher settings. The factors which determine the output rate are:

- measurement rate,
- number of analog channels in the scan,
- alarm checking,
- data blocking,
- output format,
- processing.

A scan can include input channels of any type, so the choice of measurement rate is always offered. However, if a scan contains no analog channels the choice has no significance and may be ignored.

The rate at which digital inputs are read is fixed at 500 bits/s for single bits and 1000 bits/s for bit groups. Counter-Timer readings are updated at the rate of one/second.

5.3.1.6 End-of-Scan Processing

At the end of a scan, and prior to output, the measurement results may be processed according to a user-defined program. In task definition the end-of-scan processing is simply selected on or off. The actual program instructions are entered under "Process" in the PROGRAM menu. See Section 5.4.

Typical applications of end-of scan processing are:

- Averaging measurements over time or in groups.
- Selection of more frequent measurement of critical data.
- Reduction of raw readings to a few significant results, e.g. efficiency calculations.
- Outputting control messages to user terminals.
- Calculations, such as angle of principal stress from individual strain readings.
- Control of external equipment, in accordance with measured results.

5.3.1.7 Data to be Logged

To reduce the data to be logged to a manageable amount it is possible to output data in accordance with the following conditions:

All	Log everything.
Alarm	Log only the alarm results.
Proc	Log only the processed results.
Al+Pr	Log only the alarm results and the processed results.
None	Log nothing.

Why bother to set up a task that logs nothing? One reason could be that the task is to perform a control function only; another, that the task is to check the input data for an alarm state and, should this occur, trigger a second task that measures the inputs at a much higher rate and outputs the results.

5.3.1.8 Task Header

The task headers are the "Start scan of Task" and "Done scan of Task" markers (see Chapter 7, Section 2). These may be selected for output as follows:

Always	Headers are output each time a task is actioned (whether or not data is logged).
Log Data	Headers are output only when data is logged. (See Section 5.3.1.7 above.)
NOne	Headers are not output at all. (This setting is selectable only by remote command.

5.3.1.9 Output Device

Data to be logged may be output to one of the following:

- Disk. (Contained in SI 3535D and G only.)
- Printer. (Contained in SI 3535D only.)
- RS 232.
- RS 422/a.
- Display
- GPIB.

Although only one output device can be selected under "Select Output Device", it is possible to output data to additional devices during end-of-scan processing. Note, however, that the use of one or more additional output devices may reduce the logger throughput.

It is possible to MONITOR selected input channels or the results of a task to another output device. (See Section 9.1.) This may also reduce the logger throughput.

5.3.1.10 Output Format

For each output device a selection of output data formats is available. (See Table 5.8.) The aim is to provide a format to suit each data logging requirement. A short description of each format is given below and this is supported by a full description in Chapter 7 of the manual.

Table 5.8 Output Format Availability

OUTPUT DEVICE	FORMATS AVAILABLE			
	Full	Compact	Coded	Binary
Display	•	•		
Printer	•	•		
Disk	•	•	•	
GPIB	•	•	•	•
RS232	•	•	•	•
RS422a,b	•	•	•	

•=format available.

Full Format contains all information, including text messages and results. This information is obtained at the expense of storage space on print roll, disk, etc, and consists of 40-character strings.

Compact Format contains full numeric information, i.e. results etc, but excludes text. Each result consists of a 20-character string and therefore requires less storage and recording space than full format.

Full format and compact format are intended for readable outputs on printers or displays, with an eighty character line length. With these devices, full format gives two results per line, whilst compact format gives four.

Coded Format is intended primarily for recording data on the logger disk, but data thus recorded may be saved to any other device. Each result in coded format is a binary number encoded into a string of ten printable ASCII characters. Texts are not output in coded form. Coded format takes up minimum disk space and therefore permits the maximum number of results to be recorded. Results recorded in coded format are normally replayed only in the logger. Coded format results may be replayed in coded, compact or full format.

Continued overleaf.

Binary Format is the most convenient way of exporting data (via the GPIB or the RS 232 or RS 422a,b serial interface) for subsequent processing by computer. (Binary format needs no complex decoding, prior to being used by the computer.)

Data in binary format can not be output to the display, printer, fast serial output (RS422a or b) or disk; neither can it be reconstructed from coded format data previously stored on disk.

5.3.1.11 Tasks Triggered/Aborted on Alarm

One or more other tasks may be triggered, or aborted, on detection of an alarm by the present task. This "cross-triggering" of tasks allows the logger to be programmed dynamically, so that it can change its mode of operation in accordance with significant changes in the measured data.

For example, Task 1 could be programmed to measure a group of inputs periodically to check for alarm states. Then, should an alarm occur, Task 2, specified in Task 1 as a "Task triggered on alarm", could take over to measure the inputs at a faster rate and log the results. Further, Task 2 could specify Task 3 to be triggered on a serious alarm state, perhaps to take remedial action.

(▸▸ SI 3535 Ref. Man, Section 2.20: cross-triggering remote commands XT and XA.)

5.3.2 Event Task Setups

An Event task deals only with *changes* in digital input, which are representative of a change in the status of external equipment. Inputs of this type can be obtained only through the SI 35302D Event-Status Module, from channels that are set for event capture (Section 4.2.3).

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.6.2.)

5.3.2.1 Event Channel Numbers

Enter the event channels to be interrogated. Follow the rules given in Section 5.3.1.4.

5.3.2.2 Event Enable

Under "Event Enable" you define the time "window" in which events are to be detected.

An event window can be opened by the Timer, the Clock, or another task. (The Timer and the Clock are derived from the logger's internal clock.) The logger must be in the RUN state for events to be enabled from any of these sources.

Under "Timer", enter the window opening delay. This delay can cover days, hours, minutes and seconds and starts from the time that the RUN command is given.

Under "Clock", enter the time that the event window is to open.

Under "Task", enter the window opening delay. This delay starts from the time that the present task is triggered from another. This other task includes the number of the present task as a "Task to be triggered".

5.3.2.3 Continuous/Fixed Duration Window

An event window can be defined as continuous ("Cont") or as of fixed duration ("Durat").

A continuous window, when opened as defined under "Event Enable", remains open, either until the present task is aborted by another or until the logger is HALTed. A fixed duration window remains open for the duration specified.

All events (i.e. "transitions of interest") that occur within an eventwindow are stored and output. If a higher priority task being actioned whilst an event window is open, the output of events is suspended. Events continue to be recognised, however, and are stored in the output buffer, to be output when the higher priority task has finished. ("Transitions of interest" are specified in the event channel definition.)

5.3.2.4 Event Data Output

The event data to be logged can be specified as "All" or "None".

"All" event data means all the transitions of interest (as specified in the event channel definition) and the times at which they occurred.

"None" means that no event data is to be output. This setting can be used if the intention is simply to trigger another task each time a transition of interest occurs. (See Section 5.3.2.7.)

5.3.2.5 Output Device

Event data to be logged can be output to any one of the following:

- Disk. (Contained in SI 3535D and G only.)
- Printer. (Contained in SI 3535D only.)
- RS 232.
- RS 422/a.
- Display
- GPIB.

It is possible to MONITOR selected input channels on a second output device whilst the event data are being logged, but this does reduce the logger throughput.

5.3.2.6 Output Format

Event data can be output in exactly the same formats as scan results. See Section 5.3.1.10.

5.3.2.7 Tasks Triggered/Aborted on Alarm

All events (i.e. those specified in the event channel definition as "transitions of interest") are recognized as alarms.

One or more other tasks may be triggered, or aborted, whenever an event is detected. This "cross-triggering" of tasks allows the logger to be programmed dynamically, so that it can change its mode of operation in accordance with significant changes in the status of external equipment.

On detection of an event, an event task could, for example, trigger other tasks that:

(a) take significant measurements,

(b) take remedial action.

(▸▸ SI 3535 Ref. Man, Section 2.20: cross-triggering remote commands XT and XA.)

5.4 PROCESS PROGRAM EDITING

Program instructions for end-of-scan processing of scan task results are entered under "Process" in the PROGRAM menu (see Fig 5.15 at end of chapter) using the SI 3535D front panel. Full edit facilities are available for composing and editing the program and the basic use of these is described below.

(▸▸ Full instructions on the use of the SI 3535 programming language are contained in Chapter 4 of the SI 3535 Reference Manual. Note that each program line is assigned to a specific task by a task-oriented line number.)

5.4.1 Edit Facilities

The process program edit facilities are accessed as follows:

1. Press the PROGRAM MENU key and the "Process" soft key. The message "Enter line to start editing" is now displayed.

2. Enter the program line number on which you wish to start. This should always be "1000" or greater: program lines below 1000 are not accessible to the user.

The facilities described in Sections 5.4.1.1 through 5.4.1.6 then become available.

5.4.1.1 Line Insertion

A program line can be inserted with the LINE INSERT key. The procedure is:

1. Position the cursor on the line that is to follow the inserted line, by means of the arrow keys "↓" and "↑".

2. Press LINE INSERT.

If there are any free line numbers then a blank inserted line takes up the first of these. If not, then the inserted line takes up the number of the line on which the cursor was positioned in step 1 and the numbers of all following lines are incremented by "1".

5.4.1.2 Line deletion

A program line can be deleted with the LINE DELETE key. The procedure is:

1. Position the cursor on the line that is to be deleted.

2. Press LINE DELETE.

The line on which the cursor was positioned is deleted and its line number becomes free. The numbers of all existing lines in the program are unaffected.

5.4.1.3 Line Renumbering

The renumber facility allows you to renumber the program lines by specifying the line number spacing. The procedure is:

1. Press the Renumber soft key. The message "Enter step size for renumber" is now displayed.

2. Enter the step size, e.g. "10". The specified line numbering is now implemented.

This facility is useful for spacing out a program prior to making large scale modifications.

(▸▸ SI 3535 Ref. Man, Chap. 3, Sect. 2.7.)

5.4.1.4 Edit line

The edit line facility takes you to the beginning of a specified line to start editing. The procedure is:

1. Press the "Edit line" soft key. The message "Enter line number to edit" is now displayed.

2. Enter the line number and you are at the beginning of the specified line, ready to edit.

5.4.1.5 Keywords

The keywords facility allows you to enter the reserved BASIC keywords from a cyclic list, rather than key them in one character at a time. The procedure is:

1. Press the Keyword soft key. This selects the first selection of BASIC words.

2. If the word you want is displayed, press the appropriate soft key to select it; otherwise, press the "Etc." soft key until the BASIC word you want is displayed, then select it.

3. To return to the main editing menu, press the "Top menu" soft key.

4. Repeat steps 1 through 3, as necessary, to build up the program text.

5.4.1.6 Help

Pressing the Help soft key displays a full list of BASIC keywords and symbols. Pressing any other key returns you to the main editing menu. (The function normally called up by this other key is ignored.)

6 DATA LOGGING SETUPS (SI 3535D)

Data logging setups apply to data produced in visual form by the SI 3535D data logger. The facilities which come into this category are:

- Display attributes.
- Display format.
- Printer attributes.

The setups for each of these facilities are described below, in Sections 6.1 through 6.3.

6.1 DISPLAY ATTRIBUTES

The display attributes, i.e. contrast, character size, screen mode and screen save are set under "Display" in the PROGRAM menu (Fig 5.15).

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.1.)

6.1.1 Contrast

Screen contrast can be adjusted between 0% and 100% for optimum clarity over a range of viewing angles and ambient temperatures. The adjustment for temperature is particularly useful when the logger is located in an environmental chamber. See Fig 5.7.

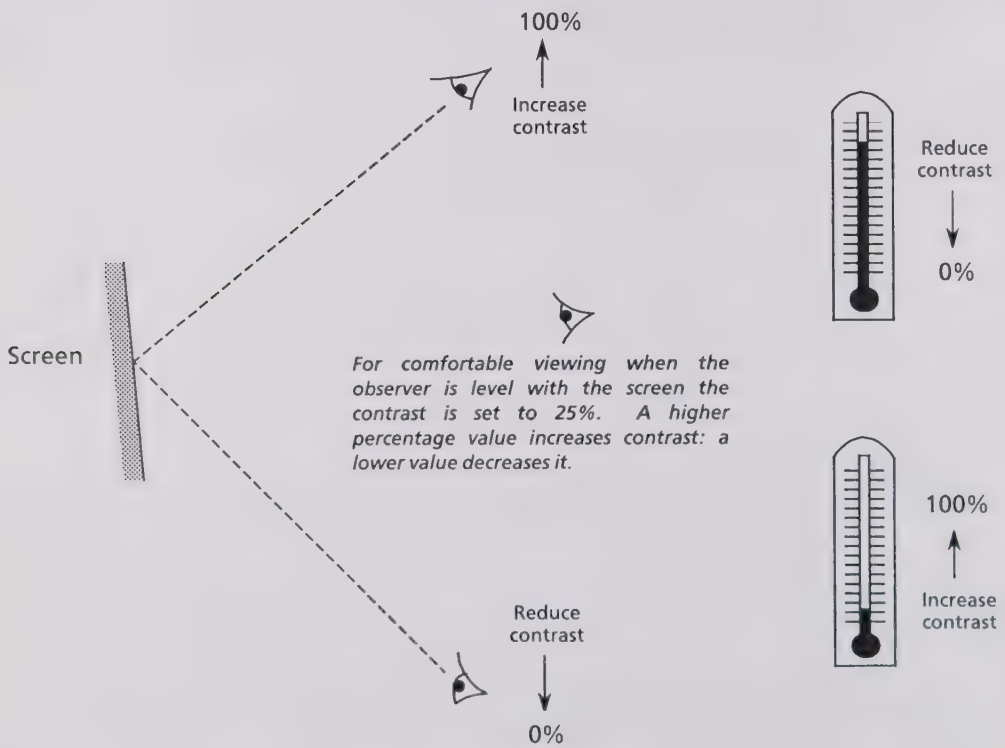

100%
Increase contrast
Reduce contrast
0%
Screen
For comfortable viewing when the observer is level with the screen the contrast is set to 25%. A higher percentage value increases contrast: a lower value decreases it.
100%
Increase contrast
Reduce contrast
0%

Fig 5.7 *Contrast adjustment, in relation to viewing angle and temperature.*

6.1.2 Character Size

The character size of displayed text can be doubled for viewing the display from a distance. This is useful when viewing displayed results, whilst adjusting the system under test. See Fig 5.8.

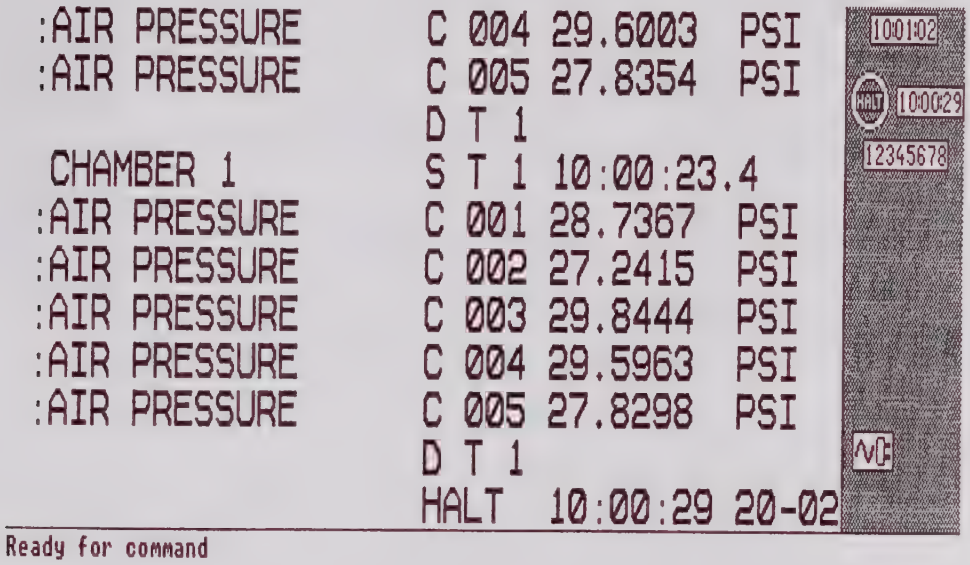

:AIR PRESSURE C 004 29.6003 PSI
:AIR PRESSURE C 005 27.8354 PSI
D T 1
CHAMBER 1 S T 1 10:00:23.4
:AIR PRESSURE C 001 28.7367 PSI
:AIR PRESSURE C 002 27.2415 PSI
:AIR PRESSURE C 003 29.8444 PSI
:AIR PRESSURE C 004 29.5963 PSI
:AIR PRESSURE C 005 27.8298 PSI
D T 1
HALT 10:00:29 20-02
10:01:02
HALT
10:00:29
12345678
Ready for command

Fig 5.8 *Example of double-sized text on display.*

6.1.3 Screen Mode

Two screen modes are available: the default "Scroll" mode and an optional "Wrap" mode. The difference between these two modes becomes apparent when the display text frame is full: the scroll mode always presents the most recent result at the bottom and "scrolls" the preceding results up the display to make room for it; the wrap mode returns to the top of the text frame and works its way down again, overwriting each result in turn as a new one becomes available.

6.1.4 Screen Save

The screen save facility can be used to prolong the life of the screen backlight. When enabled, the facility monitors the pressing of the front panel keys: if about fifteen minutes have elapsed since the last key press then the screen backlight is switched off. Pressing any key immediately switches the backlight on again.

6.2 DISPLAY FORMAT

The four display formats available are "Text", "Template", "Bargraph" and "Trends". Each format is described below.

Text: Data appears line by line in alphanumeric form and the screen mode affects how it scrolls. This is the default format.

Template: This format provides for customized displays, including fixed text and data from particular channels.

Bargraph: This format gives a graphical representation, in which a channel value is shown as a bar between limits set by the user.

Trends: This format provides a graphical representation of logged data.

Data in each format can be displayed together, except trends and bargraphs (only one can be selected at any one time). See the example in Fig 5.9.

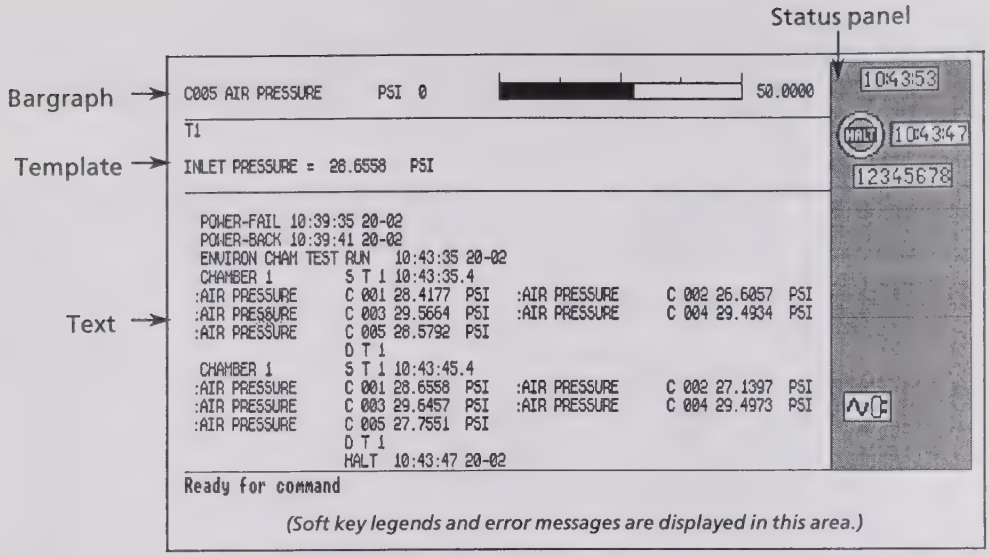

Status panel
Bargraph
Template
Text
C005 AIR PRESSURE PSI 0
50.0000
T1
INLET PRESSURE = 28.6558 PSI
POWER-FAIL 10:39:35 20-02
POWER-BACK 10:39:41 20-02
ENVIRON CHAM TEST RUN 10:43:35 20-02
CHAMBER 1 S T 1 10:43:35.4
:AIR PRESSURE C 001 28.4177 PSI :AIR PRESSURE C 002 26.6057 PSI
:AIR PRESSURE C 003 29.5664 PSI :AIR PRESSURE C 004 29.4934 PSI
:AIR PRESSURE C 005 28.5792 PSI
D T 1
CHAMBER 1 S T 1 10:43:45.4
:AIR PRESSURE C 001 28.6558 PSI :AIR PRESSURE C 002 27.1397 PSI
:AIR PRESSURE C 003 29.6457 PSI :AIR PRESSURE C 004 29.4973 PSI
:AIR PRESSURE C 005 27.7551 PSI
D T 1
HALT 10:43:47 20-02
10:43:53
HALT
10:43:47
12345678
Ready for command
(Soft key legends and error messages are displayed in this area.)

Fig 5.9 *Example of display formats.*

Note: Textual results are buffered for fast measurements, whereas bargraph, template and trend graph results are always updated in real time. Therefore, textual results may sometimes lag slightly behind bargraph, template and trend results.

6.2.1 Setting Up a Template

The template facility gives you complete freedom in customising your display format. Templates are set up under "Template" in the PROGRAM menu (Fig 5.14).

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.12. **NOTE**: Remote commands can be used to select templates on/off and to define the data source, but not to edit templates.)

The procedure, using local control, is as follows:

1. Press the PROGRAM MENU key, then the "Template" soft key. The message "Enter template number [1-9] " is now displayed.

2. Enter a template number, e.g. "1". (This number identifies the template for subsequent recall, so it is a good idea to include it in the displayed text. See step 4.)

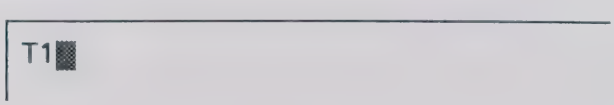
3. Press the "Edit" soft key. The display now changes to the template edit mode and shows anything currently included in the template specified in step 2.

   From initial conditions, a template contains only a small rectangular cursor which appears in the top left hand corner of the screen. A message in the bottom right hand corner of the screen reminds you that you are "Editing template 1".

4. Should you wish to display the template number, key it in now, e.g. "T1".

   Alphabetic characters are made available on the keypad by pressing the SHIFT key once: a further press returns you to the numbers and the miscellaneous characters such as brackets and stops.

   The display now shows:



5. Further user text can be placed anywhere on the screen. Simply position the cursor where you wish the text to start, with the arrow keys. For example, position the cursor at the beginning of line three by pressing the arrow keys: ↓ ↓ ←.

   On the presently selected line you can, if you wish, key in what a particular value represents, e.g.

   ```
   T1

   BOILER PRESSURE 1=
   ```

   Should you make a mistake when keying in text, several edit facilities are available to help you correct it. If you key in an incorrect character, simply position the cursor over it and type in the correct character. If you wish to delete a character, position the cursor immediately to the right of the character (if necessary, over the adjacent character) and press the CHAR DELETE key. Insert an extra character by positioning the cursor over the character that you intend the inserted character to precede. Lines can be inserted or deleted in a similar way to characters.

6. To define the source of a value to be displayed enter a "marker". This can be either a *channel* marker or a *process* marker. Select either one by pressing the "Channel" or "Process" soft key.

   Assuming that the source of "BOILER PRESSURE 1" is channel 1, press the "Channel" soft key and enter the appropriate channel number, i.e. "1". The channel marker is now displayed:

   ```
   T1

   BOILER PRESSURE 1=***C001***
   ```

   A similar marker is entered for a process.

   When measurements are made, a marker is replaced by the corresponding measured or processed value.

7. Further user text, such as the units of the displayed value, may be keyed in to follow the displayed value, e.g.

   ```
   T1

   BOILER PRESSURE 1=***C001***LBS/SQ.IN
   ```

8. Key in any further text and markers that you wish to be covered by the present template, then press the "Exit" soft key. The presently selected template should reappear on the display, ready to display data in accordance with the specified marker(s).

Having set up several templates you can key in the one most suited to your present logging operation. Simply press the PROGRAM MENU key and the "Template" soft key, enter the appropriate template number, and select template "On".

The source of the template results may be selected as "Monitor" or "Task", under the "Results" branch of the template menu.

6.2.2 Setting Up a Bargraph

Bargraphs give a graphical indication of channel or process values, between user-defined limits. Bargraphs are set up under "Bargraph" in the PROGRAM menu (Fig 5.14). (▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.11.)

The procedure for setting up a bargraph, using local control, is as follows:

1. Press the PROGRAM MENU key and the "Bargraph" soft key. The message "Enter bargraph number [1-10]" is now displayed.
2. Enter a bargaph number, e.g. "1". The message "Enter low;high limit for bargraph" is now displayed.
3. Enter the bargraph limits, in accordance with the expected range of values, e.g. 100;2000.
4. Select a "Channel" or "Process" source for the data.
5. Select bargraph "On". The bargraph is now displayed, at the top of the screen. The bargraph is updated whenever the designated channel is measured.

6.2.3 Setting Up a Trend Graph

The Trend graph facility enables a graphical representation of logged data for the user. The facility is set under the "Trends" softkey in the PROGRAM menu (Fig 5.16).

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.13. Note: Trend graphs are only available on the SI3535D.)

The procedure for setting up a trend graph, using local control, is as follows:

1. Press the PROGRAM MENU key, then the "Trends" soft key. The message "Select trend graph setup function" is displayed.
2. Select "Type". The message "Select trend graph type" is displayed. The selection of either "Separate" or "Overlay" now becomes available.

   Upto a maximum of 4 trends may be enabled at one time. These may be displayed as separate graphs or as overlay trends on a single graph.

   The separate graph method should be used when the sources provide results which are significantly different in value or type, e.g. voltage and temperature measurements.

   The overlay graph method should be used when the sources provide results which are of similar values and type. There is no method of combining separate and overlay graphs; the selection is one or the other.

3. Select "Separate". The message "Select item to be defined" is displayed. The selection of either "Time axis" or "Line type" is now available.
4. Select "time axis" and select the required axis duration from the softkeys provided.

   Once selected the choice of time axis or line type will again be available.

5. Select "line type". The message "Select line type" is now available; with the choice of "Solid, Dot, Dash or Wide Dash".

   This selection represents the four distinct data sources. When the overlay trend graph is selected the graph is annoted with a key at the top of the display to show which line corresponds to which data souce.

6. Once the line type has been selected the message, "Select item to be defined" is displayed. The selection of "mode, vert. axis, label, or source" becomes available.

"Mode" allows you to turn on/off the particular data source being edited.

"Vert. Axis" allows you to select the max & min values for the Y-axis. No autoscaling is provided, so scaling must be done manually. When using overlay trend graphs the vert. axis is defined at the same time as the "time axis" due to all trends being on the one graph.

"Label" allows upto eight characters maximum, to be entered as a label to a particular trend.

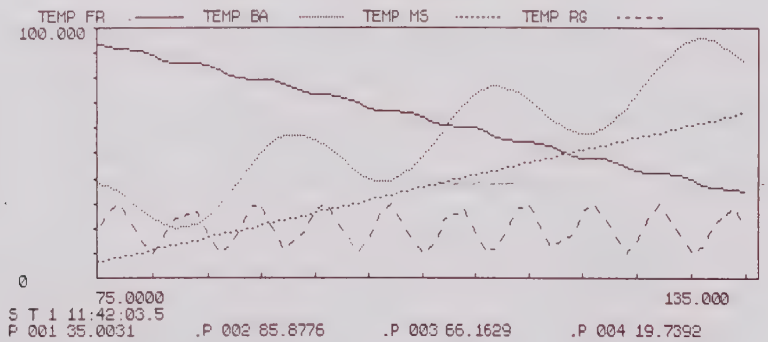
"Source" allows the data source to be selected; Mode must be off to allow the source to be changed. The data source may be one of the following:

(i) A single monitored channel. Any channel measured using the monitor facility may be displayed.

(ii) A single channel from a specified task scan.

(iii) A single processed result from a specified task scan.

The overlay mode is setup in a similar manner but with the trends displayed on the same graph. An example of an overlay trend graph is shown below :



On the trend graphs the time shown along the bottom of the trend is the number of seconds since the first result was measured. The maximum permitted interval between two results to be trended is 23days. It should also be noted that it is not possible to create a trend from digital inputs.

There are also the options of the grid and autoprint. The grid is only available to a maximum of two trends, after which the grid is automatically switched off. The autoprint allows an automatic screen dump whenever the trend display is full, prior to scrolling. To change the printer attributes, in order to change to horizontal output, refer to section 6.3.

6.3 PRINTER

When selected as an "Output Device" in the task definition menu the printer outputs textual results. Alternatively, when the "Print Screen" soft key in the CONTROL menu (Fig 5.17) is pressed, the printer outputs a replica of what is present on the display, including the status panel and any barcharts or templates. The printer can also be used to print data previously stored on disk, and to list control information. (See Sections 7.3.4 and 7.6.) (▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.20.)

The printer "attributes", i.e. output mode, view facility and output buffering are set up under "Printer" in the PROGRAM menu (Fig 5.15). See Sections 6.3.1 through 6.3.3 below. (▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.1.)

6.3.1 Output Mode

The printer mode can be set for *normal, inverted* or *horizontal* output. Normal printout can be read as it emerges from the printer slot, whereas the inverted printout is upside down. The advantage of using an inverted printout is that the results are printed in chronological order, which makes it easier to follow any trends in the recorded data. The horizontal mode would normally be selected if trend graphs are to be printed.

6.3.2 View Facility

The View ("popout") facility, when selected, feeds the printer paper forward at the end of a printout, so that you can read the complete record. To ensure that this does not insert unwanted gaps the paper is drawn back again, just before the next printout starts.

The view facility is not intended for use when printed records are constantly being torn off. However, should it be necessary to tear off a record with "View On" selected, press paper advance once and then tear off the record. Selecting paper advance cancels the recoil command so that the paper doesn't get drawn back into the instrument before the next printout.

6.3.3 Output Buffering

Should the printer run out of paper it stops automatically, thus avoiding damage to the print mechanism. To allow logging to continue, buffering can be used to store the results that would otherwise have been printed. Once the buffer is full, however, the logging program is halted. To avoid halting the program the buffering facility may be switched off, but the results that would have been printed are lost.

7 SPECIAL MEASUREMENT FACILITIES

Special measurement facilities are available for ensuring that measurements are made with the utmost precision. These facilities are described in Sections 7.1 through 7.7 below.

7.1 STRAIN GAGE INITIALIZATION

Strain gage channels should be initialized in order to measure their zero stress outputs. When the numbers of these channels are entered, under "Init Chan" in the PROGRAM menu (Fig 5.15) the logger immediately measures the specified channels and stores the zero load values. These values are subtracted from the measured strain values to obtain a true result. (See Chapter 2, Section 3.4.6.)

In addition to measuring the zero stress values, channel initialization sets up measurement autoranging.

Channel initialization is done with the logger in the HALT state, just before the strain measurements are made.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.1.)

7.2 USER-DEFINED REFERENCE TEMPERATURE VALUES

Four user-defined reference values for temperature measurements with a thermocouple may be entered under "Init Ref" in the PROGRAM menu (Fig 5.15). These values are entered against reference numbers Ref 1 through Ref 4 and are specified by the same numbers in defining the thermocouple channel. (See Section 4.2.1 in this chapter and Section 3.5.2 in Chapter 2.)

(▸▸ SI 3535 Ref. Man. Chap. 3, Sects 2.1 and 2.3.1.)

7.3 THERMAL COMPENSATION

Thermal compensation is used to compensate for the effect of parasitic thermocouples and may be selected for ohms, PRT or strain gage measurements individually, in the channel definition. Should this effect be negligable or unimportant then thermal compensation may be switched off to increase the measurement rate. (See Chapter 2, Section 4.5, for more information.)

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.3.1, and Appendix B : Sensor Number Tables.)

7.4 DRIFT COMPENSATION

Variations in measurement results, due to changes in the logger's internal temperature affecting the performance of the ADC, are compensated for by drift compensation. This facility is normally on, but can be switched on or off by remote command at the discretion of the user. (See Chapter 2, Section 4.6, for more information.)

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.8.)

7.5 TIME TAGGING

A time tag can be added to every measurement made by the logger, thus enabling the exact time of measurement (to the nearest 2ms) to be recorded with the data. This facility is selectable under "Time tag" in the PROGRAM menu (Fig 5.15). Time tagging can be used only for full or binary format outputs.
When full format is used the time tag replaces the text area and has the following formats:

For American English: *(sp)*%hhmmss.lll*(sp)*mmddyy
For other languages: *(sp)*%hhmmss.lll*(sp)*ddmmyy

where *(sp)* represents a space character.

Normal results are preceded with "*(sp)*%" (as shown above) whilst alarm results are preceded by "*(sp)*&".

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.9.)

7.6 CLOCK SYNCHRONIZATION

Where several loggers (e.g. the SI 3535F/G measurement "front ends") are connected into a computer controlled system it is important that their clocks are synchronized precisely.

Three remote commands are available for just this purpose and are applied, by the system controller, to each logger in turn. An SY? command returns the present clock setting to the nearest millisecond. Two other commands, SY FA? and SY SL? are used for clocks that are fast or slow, respectively, and adjust the time in 5ms steps.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.21.)

7.7 DIGITAL INPUT/OUTPUT RESET

By default, the outputs of the SI 35302B Digital Input/Output Module are reset whenever the logger is halted. To avoid this, an RD OF remote command is available to switch the reset off. Another command, RD ON, switches the reset back on when required. The present state of the reset can be queried with an RD? command.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.10.)

8 DISK DRIVE

In the SI3535D and SI3535G loggers a disk drive is incorporated. This records information on a 3.5 inch double-sided double-density floppy disk, with 80 tracks/side; the SI3535 loggers do not support high density disks (see Chapter 8). The disk can be formatted to either of two standards: IBM MS-DOS (from version 3.2) and HP-LIF.

The information stored on the disk may consist of programs and/or measurement results.

A stored program contains all setup information and processing programs for up to eight tasks. When the disk is formatted a slot is allocated for each program; the amount of space left over can be used for storing results. Three programs can be stored in HP-LIF format, whilst four can be stored in MS-DOS format.

Data can be recorded on disk in either of two modes, *normal* or *cyclic*, as selected under "Disk Mode" in the PROGRAM menu (Figure 5.15). In the normal mode, data is recorded on the disk until the disk is full. The logger then goes into the pause state and data that would otherwise have been output to the disk is stored temporarily in a 5000 result buffer. In the cyclic mode, data continues to be recorded on the disk when the disk is full. Data already recorded is overwritten by newly-logged data, progressing from the earliest recorded data to the more recent. This ensures that the disk always contains a record of the latest data.

8.1 DISK CAPACITY

The number of results that can be stored on a disk depends on:

(a) the standard format used, i.e. HP-LIF or MS-DOS,
(b) the number of program slots allocated,
(c) the output format used: full, compact, or coded.

Table 5.9 lists the *approximate* number of results that can be stored in accordance with items (a) (b) and (c) above.

Table 5.9 Maximum Number of Results that can be Stored on Disk

HP-LIF				MS-DOS			
Program Slots Allocated	Output Format			Program Slots Allocated	Output Format		
	Full	Compact	Coded		Full	Compact	Coded
0	14,995	28,625	52,480	0	17,375	33,175	60,820
1	10,782	20,584	37,738	1	13,165	25,134	46,080
2	6,564	12,532	22,976	2	8,947	17,082	31,317
3	2,346	4,480	8,213	3	4,729	9,029	16,554
-	-	-	-	4	512	977	1,792

8.2 DISK HANDLING

Four facilities are available for disk handling: Format, Directory, Erase and Unload. These facilities are accessed under "Disk" in the CONTROL menu (Fig 5.19). Each one is described below, in Sections 8.1.1 through 8.1.4.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.14.)

8.2.1 Formatting

All disks must be correctly formatted before they can be used. The things to be defined are: the standard format (HP-LIF or MS-DOS) the disk volume name, and the number of program slots to be allocated. Formatting a disk takes about one minute and forty seconds. **N.B.** Disks *must* be formatted in the logger.

8.2.2 Directory

The directory of a disk contains the following information:

- The volume name and/or number.
- The standard format.
- The number of storage bytes used against the number available.
- The program slots allocated, with the names of the programs stored (if any).

The directory may be output to the printer, display or the RS 232 interface.

8.2.3 Erase

Erasing a disk deletes all measurement results, but leaves any stored programs intact. Any program no longer required can be overwritten with another: or the disk can be reformatted to reduce the number of program slots allocated, if necessary to zero.

8.2.4 Unload

"Unloading" a disk prepares it for removal from the logger when this is set manually into the Pause state. See Sections 3 and 4.1 in Chapter 8 of this manual.

8.3 SAVING A PROGRAM TO DISK

Once a disk is formatted to include a program slot, programs can be saved to the disk with the "Save Prg" facility in the CONTROL menu (Fig 5.17). Before saving a program it is wise to request a directory of the disk to check what programs (if any) are already stored: a saved program automatically overwrites any existing program in its assigned slot.

Should you wish the logger to "boot-up" from a program on disk then save this program in Slot 1. This slot is the only one used by the boot-up facility.

When saving a program you are prompted to enter the program title. Any title entered subsequently appears at the beginning of the logger output whenever the program is executed.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.14.)

8.4 LOADING A PROGRAM FROM DISK

A program previously saved on disk can be loaded back into the logger. This is done with the "Load Prg" facility in the CONTROL menu (Fig 5.17). Any program already in memory is overwritten.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.14.)

NOTE: The program saved in Slot 1 of the disk is loaded automatically if the following apply:

(a) the "boot-up" facility is in operation (see Section 4.2 in Chapter 3)

(b) the program in memory is corrupted.

8.5 REPLAYING RESULTS FROM DISK

"Replay" in the CONTROL menu (Fig 5.18) allows the results stored on disk to be output to any output device. The results for replay may be selected on the basis of type, task, channel and the time they were logged. The following selections are possible :

All	Replay all types of results or from a specified task / channel
Alarms	Replay all alarm results or from a specified task / channel
Events	Replay all event results or from a specified channel
Markers	Replay markers only
Abort	Stops result replay

All of the results maybe output between start and end times if required. When replaying by time you may omit the month or the month and day from the start and end times. If you decide to do this, ensure that they are omitted from both start and end times. Entering a zero for the month or month and day will have the same effect.

When replay is started there may be a delay before results are output. This is because the data file must be searched for the results which match the selection. It takes approximately 2 minutes to search a full disk.

Replay between times only works when time data is logged onto disk. If you log data without using start task headers or time tagged results then the replay between times will not work.

If there is only one scan per day then the replay between times cannot ascertain day/month correctly and may start the replay one day after the intended start time.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.14.)

9 GETTING RESULTS

Measurement results can be obtained in any one of three ways, as described below in Sections 9.1 through 9.3.

9.1 MONITOR

"MONITOR" has a menu of its own (Fig 5.10). This facility allows you to look at the data from particular channels or tasks, or just the data headers, irrespective of the tasks set up.

This facility is useful for checking that a channel is measuring correctly, or that a task is properly set up, whilst the main tasks proceed. A "quick look" at the data can thus be taken, for the early detection of any experimental problems.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.15.)

9.2 "RUN", "HALT", "PAUSE" AND "GO"

These are the "start" and "stop" commands for the programmed tasks. The first three commands can be given locally or remotely, whilst "GO" is a remote command only. The functions of these commands are as follows:

RUN	The logger becomes operational. Each programmed task starts when it is triggered. Whilst the logger is in the run state the channel and task setups may be queried, but not modified.

HALT All programmed tasks are halted. All setups may be modified.

PAUSE Suspends the output of data from the logger. The programmed tasks continue and any data for output is stored in a output buffer, which can hold at least 5000 results. Should the buffer become full then task operation is suspended.

GO Cancels the pause state and allows the output of data to continue. Pressing the PAUSE key a second time has the same effect.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.20.)

9.3 MEASURE

An immediate measurement on a single specified channel can be obtained with the remote command "MEasure". With this, you specify the measurement rate for analog inputs, the output format, and the channel number.

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.17.)

10 QUERYING A LOGGER SETUP

Two commands, LIST and QUERY, allow you to query the logger setup. See Sections 10.1 and 10.2 below.

10.1 LIST

"List" in the CONTROL menu (Fig 5.17) provides a list of:

- Channel setups. (Enter the channel number.)
- Task setups. (Enter the task number.)
- Conversion formulae. (Enter the conversion number.)
- Text. (Enter the text number.)
- Process program. (Enter the program line number(s).)

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.18.)

10.2 QUERY

Individual setup parameters can be queried by appending the associated remote command code with a question mark (?).

(▸▸ SI 3535 Ref. Man. Chap. 3, Sect. 2.21.)

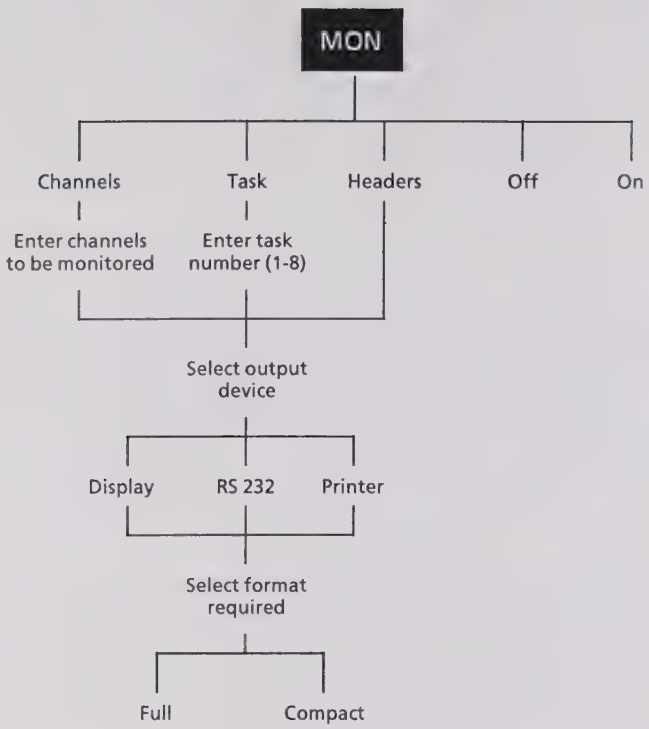


Fig 5.10 *MONITOR menu.*

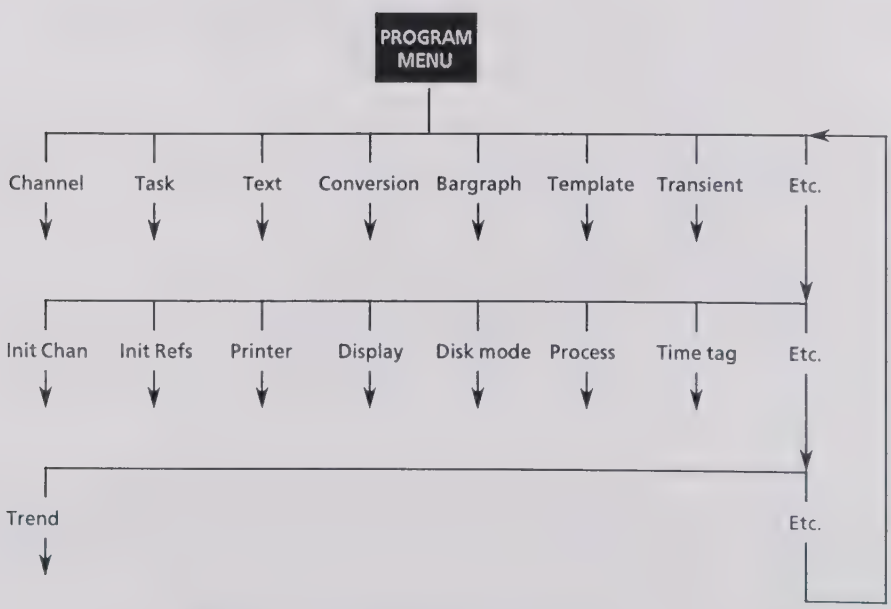


Fig 5.11 *PROGRAM menu: top level.*

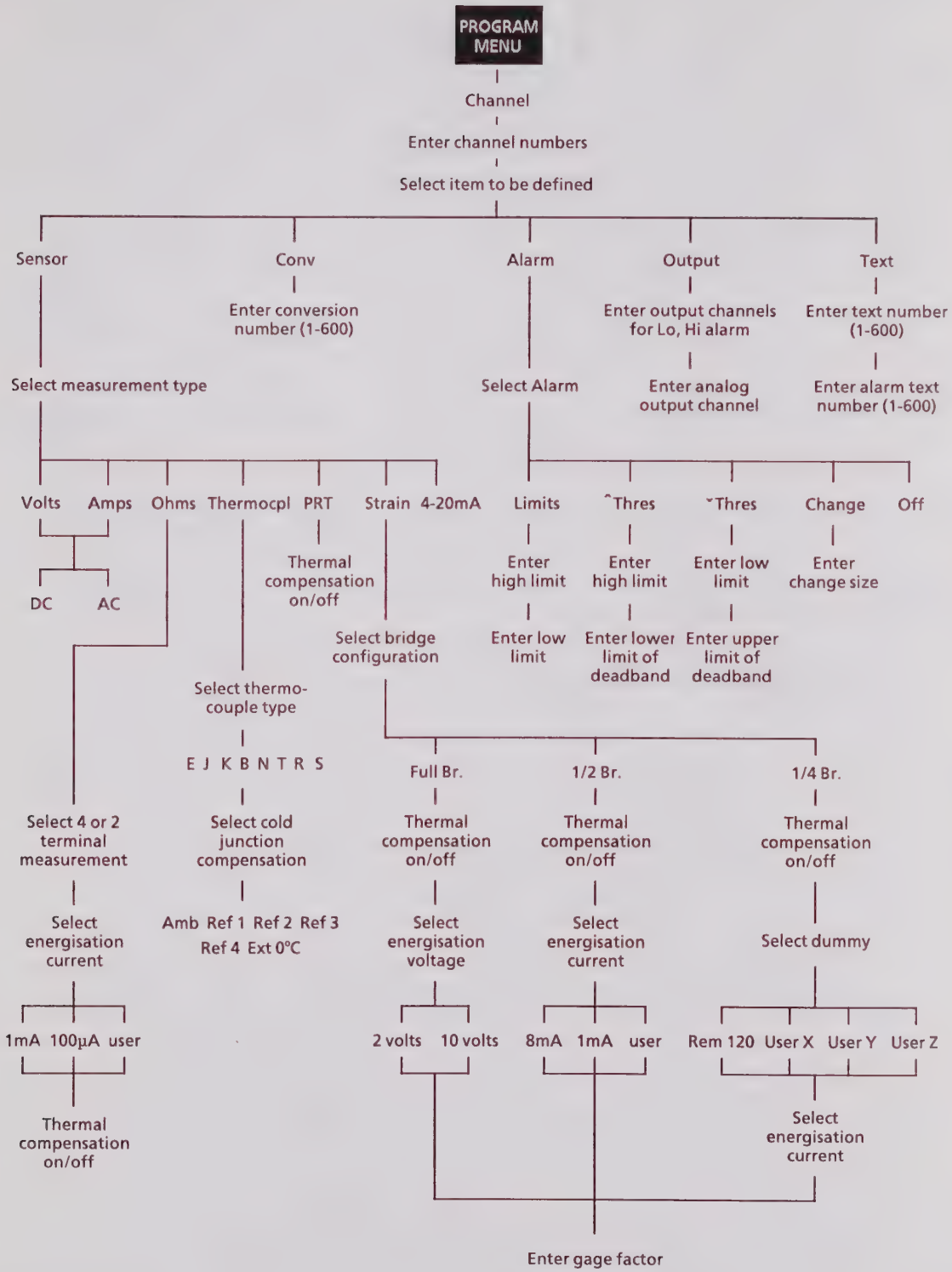


Fig 5.12a *PROGRAM menu: Channel setups for analog inputs.*

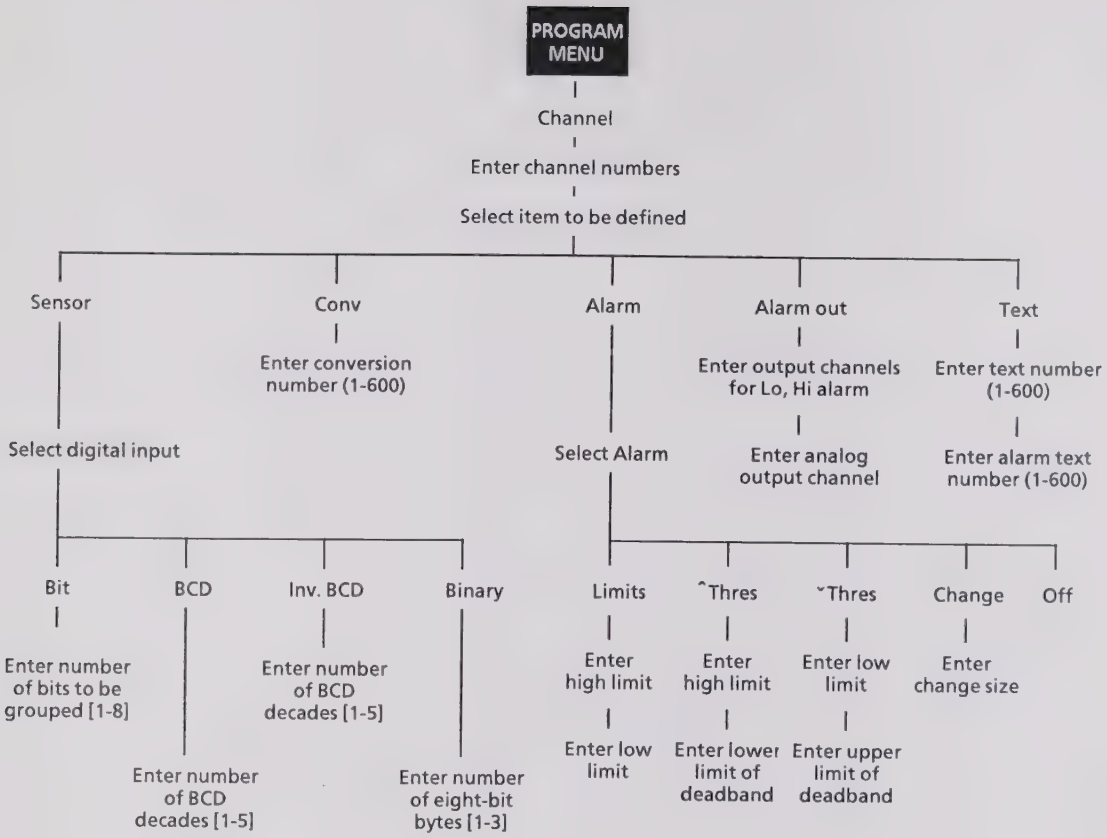


Fig 5.12b *PROGRAM menu: Channel setups for digital inputs.*

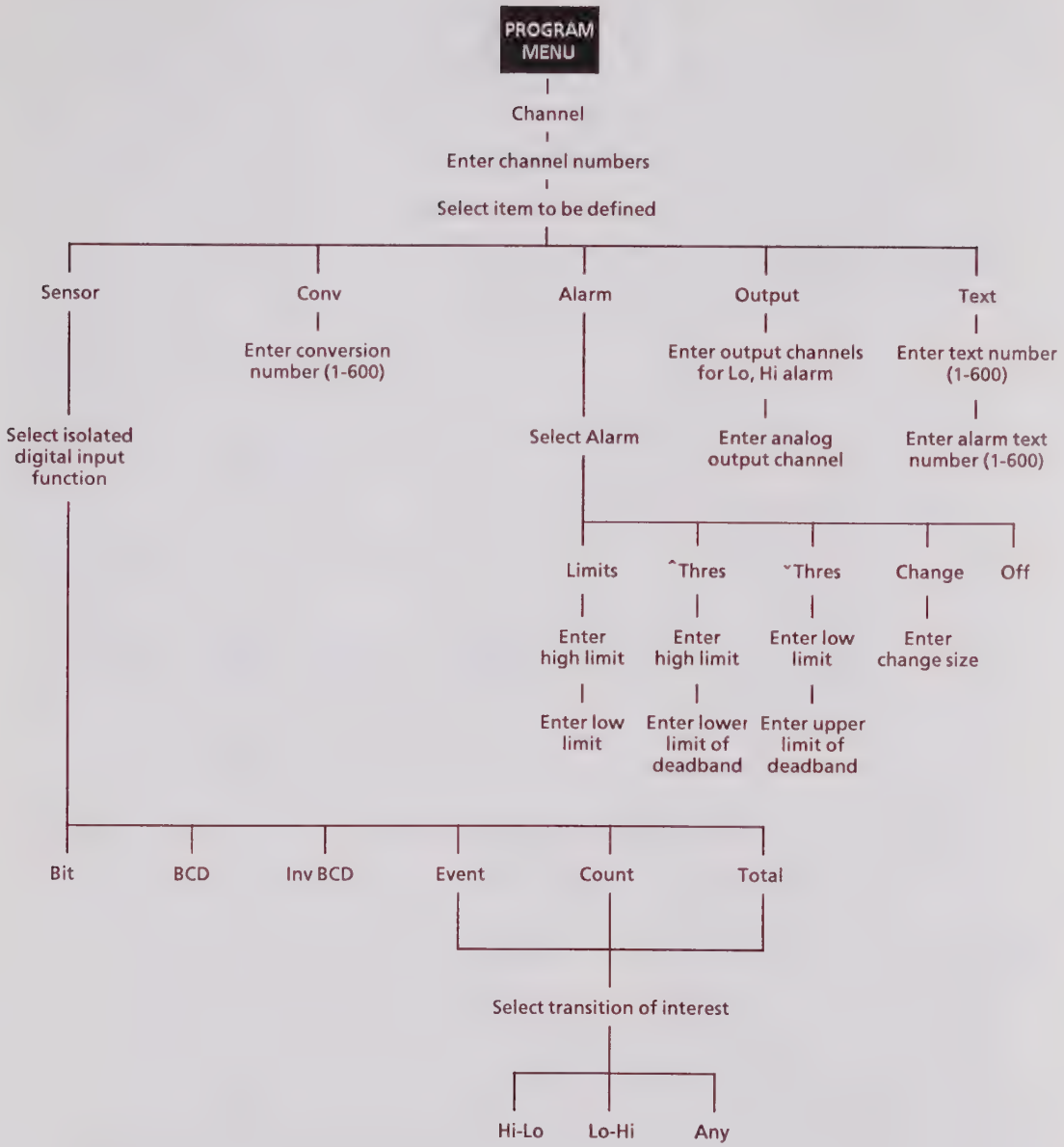


Fig 5.12c *PROGRAM menu: Channel setups for event-status inputs.*

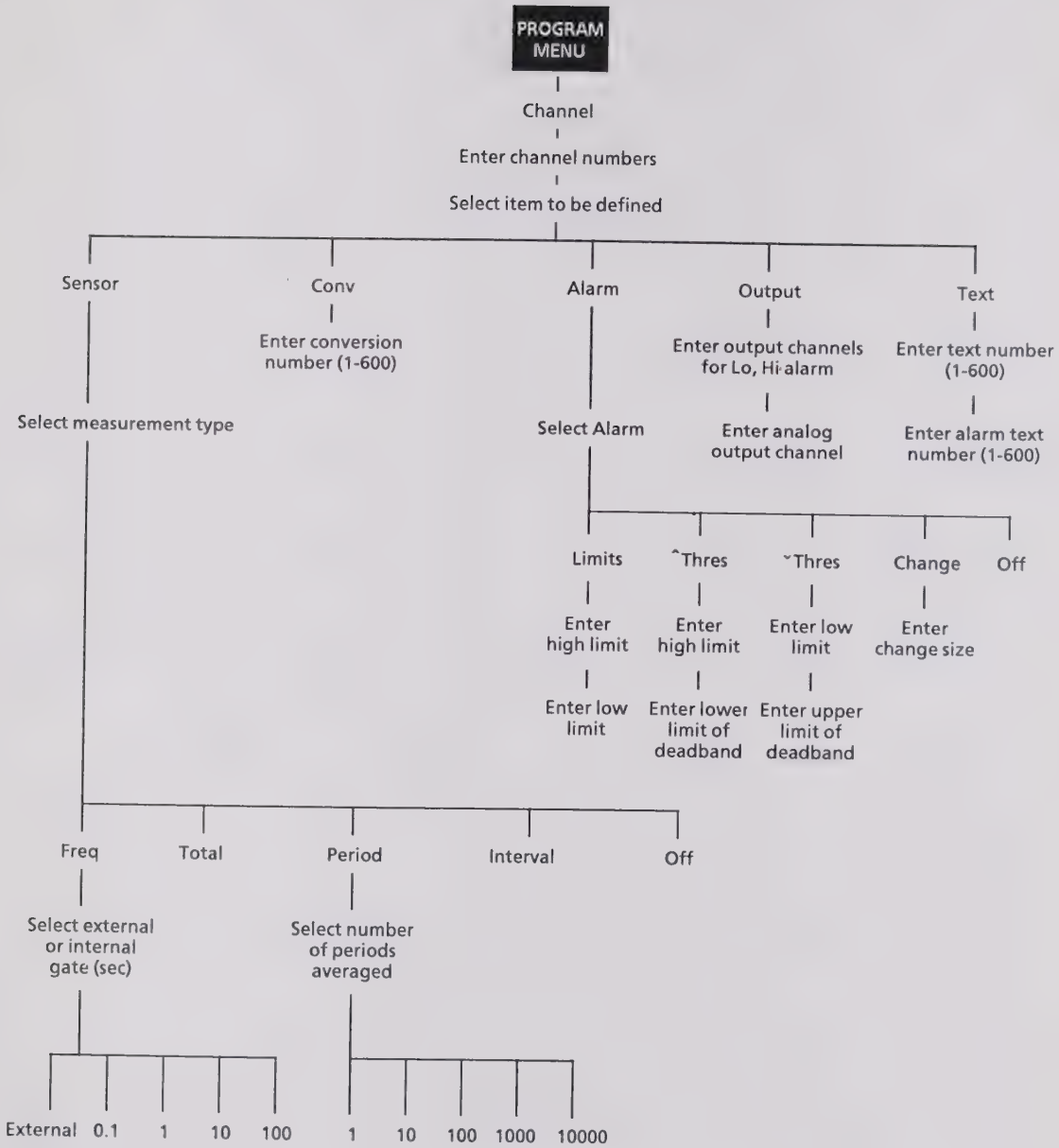


Fig 5.12d *PROGRAM menu: Channel setups for counter-timer inputs.*

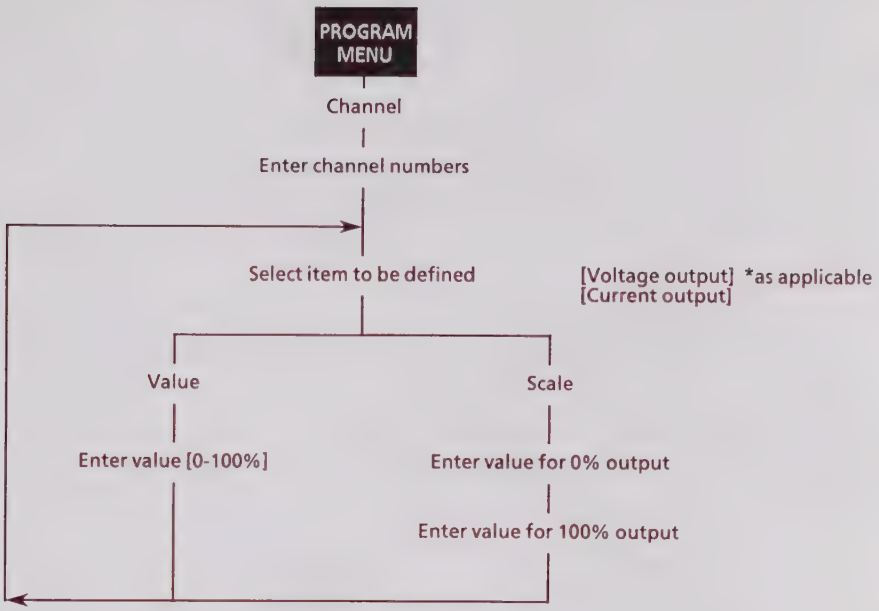


Fig 5.12e *PROGRAM menu: channel setups for analog outputs.*

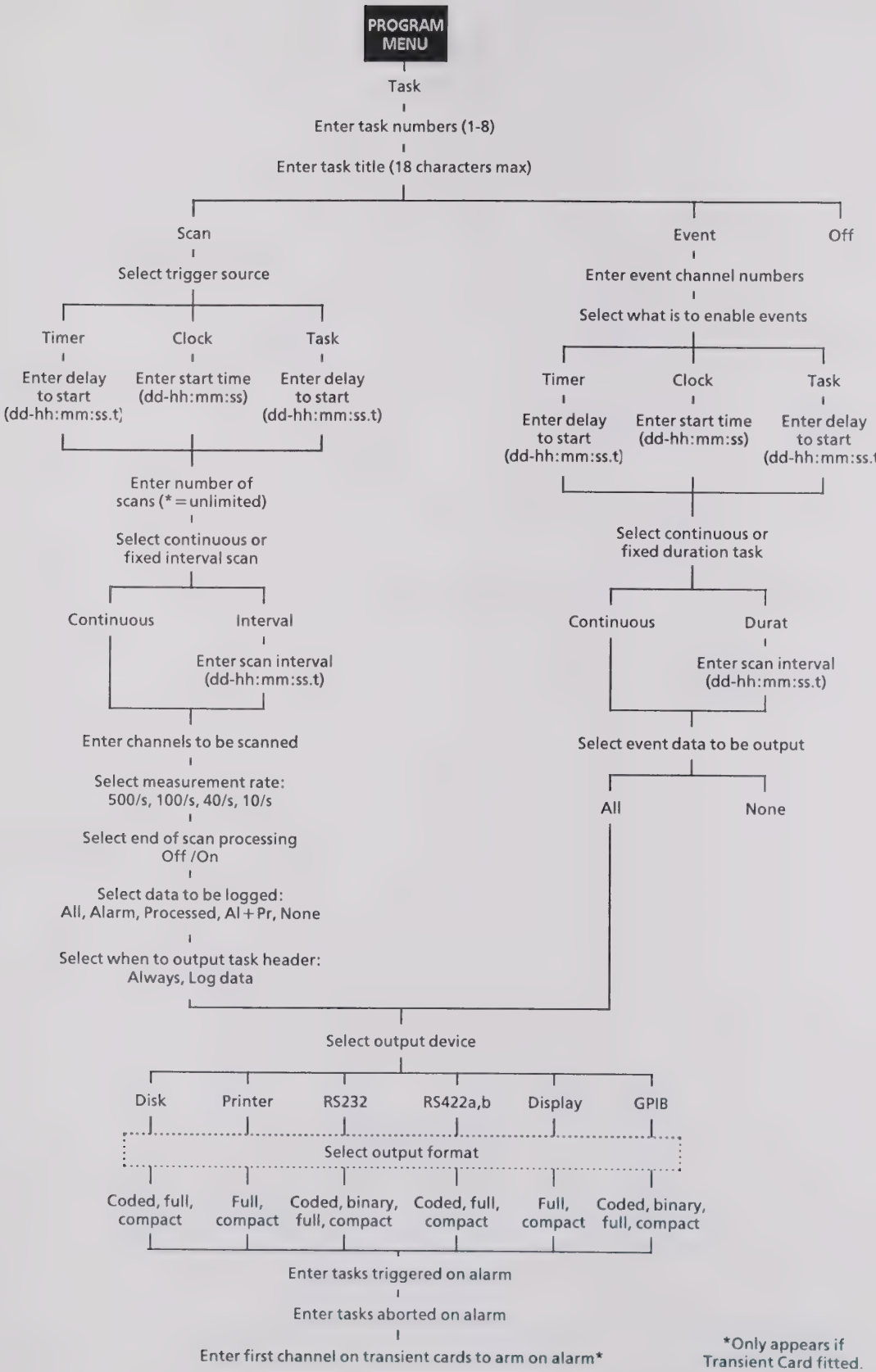


Fig 5.13 *PROGRAM menu: task setups.*

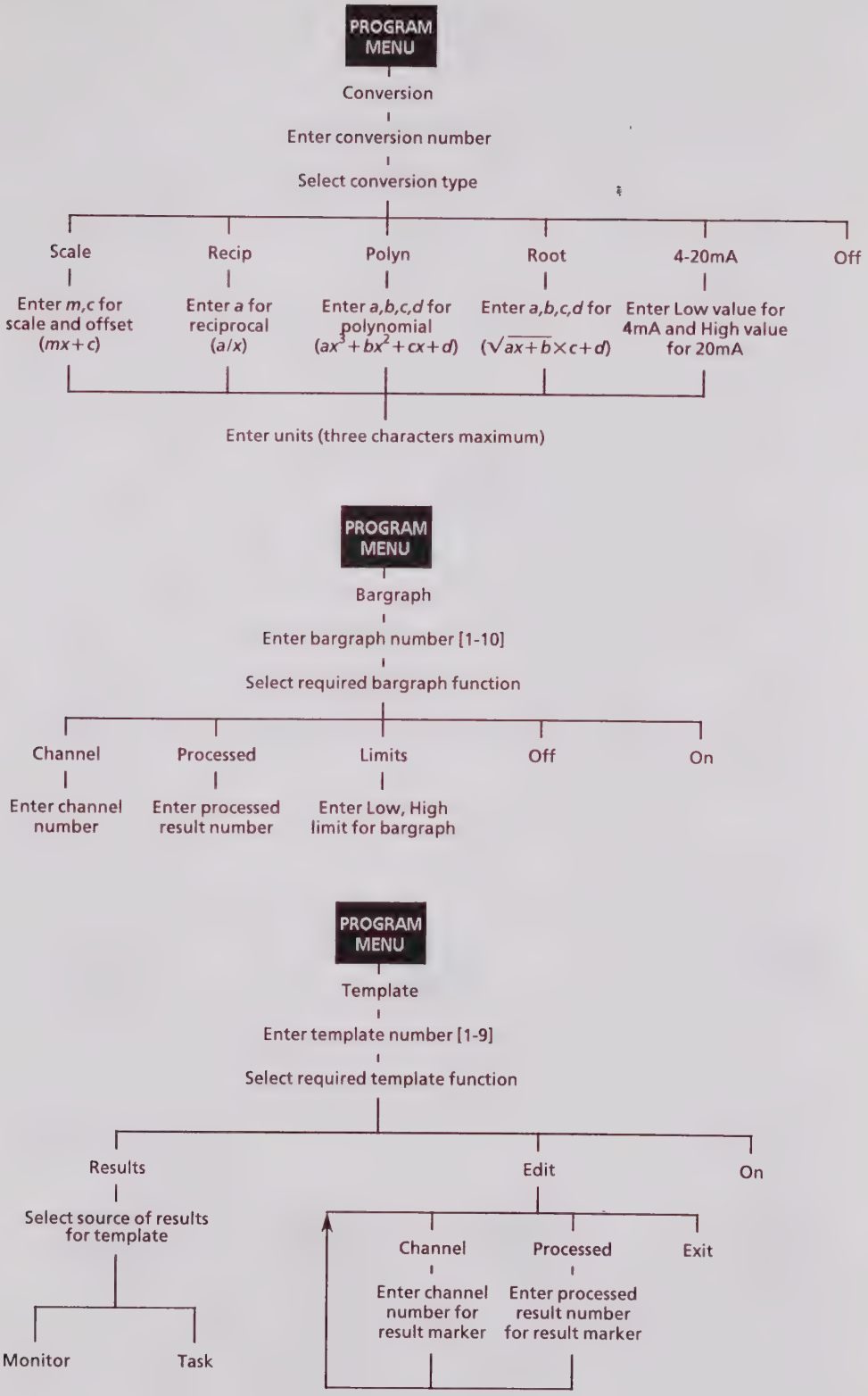


Fig 5.14 *PROGRAM menus for conversion, bargraph and template.*

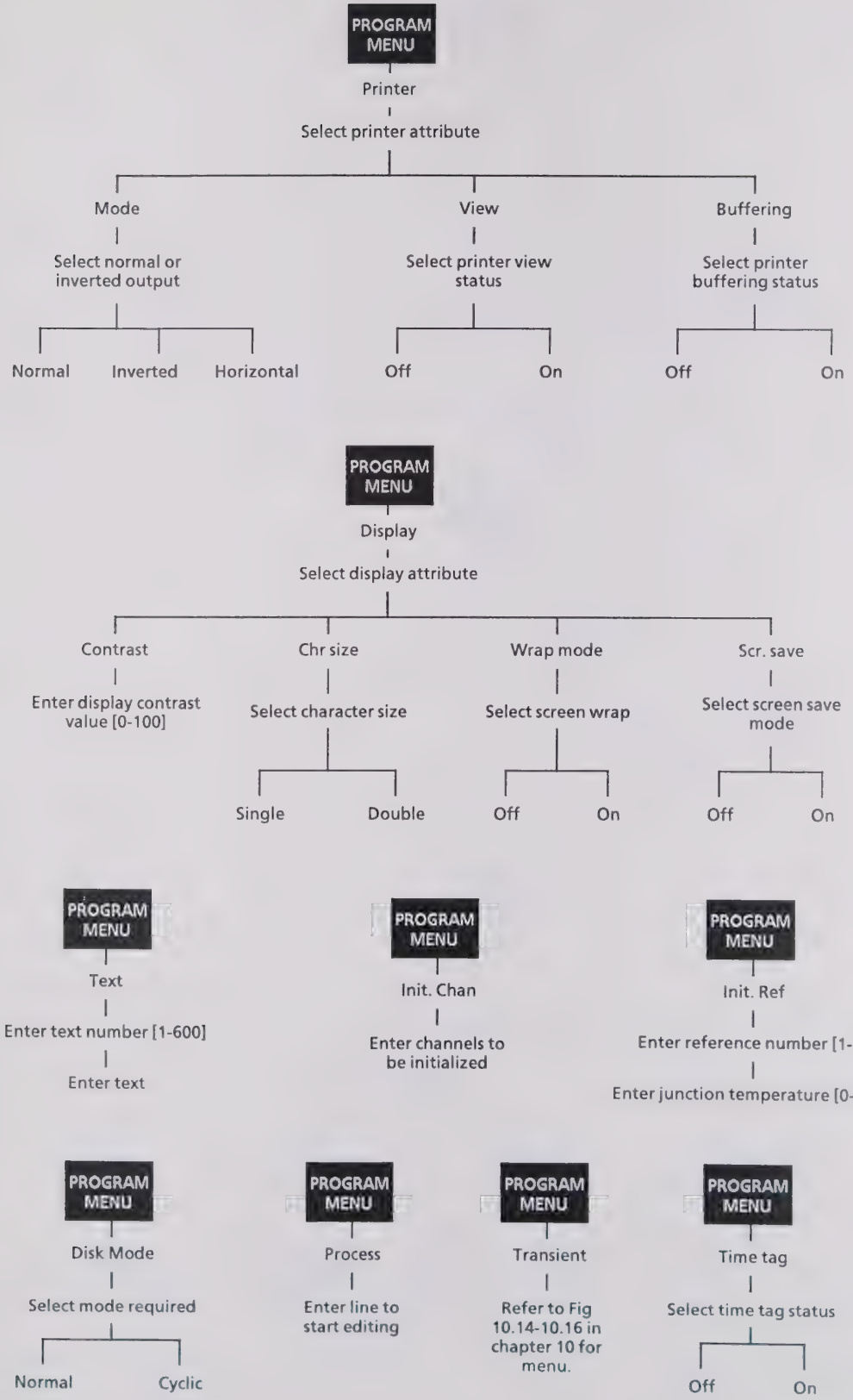


Fig 5.15 *PROGRAM menus for printer, display, text, intitialize channel, initialize reference, disk mode, process and time tag.*

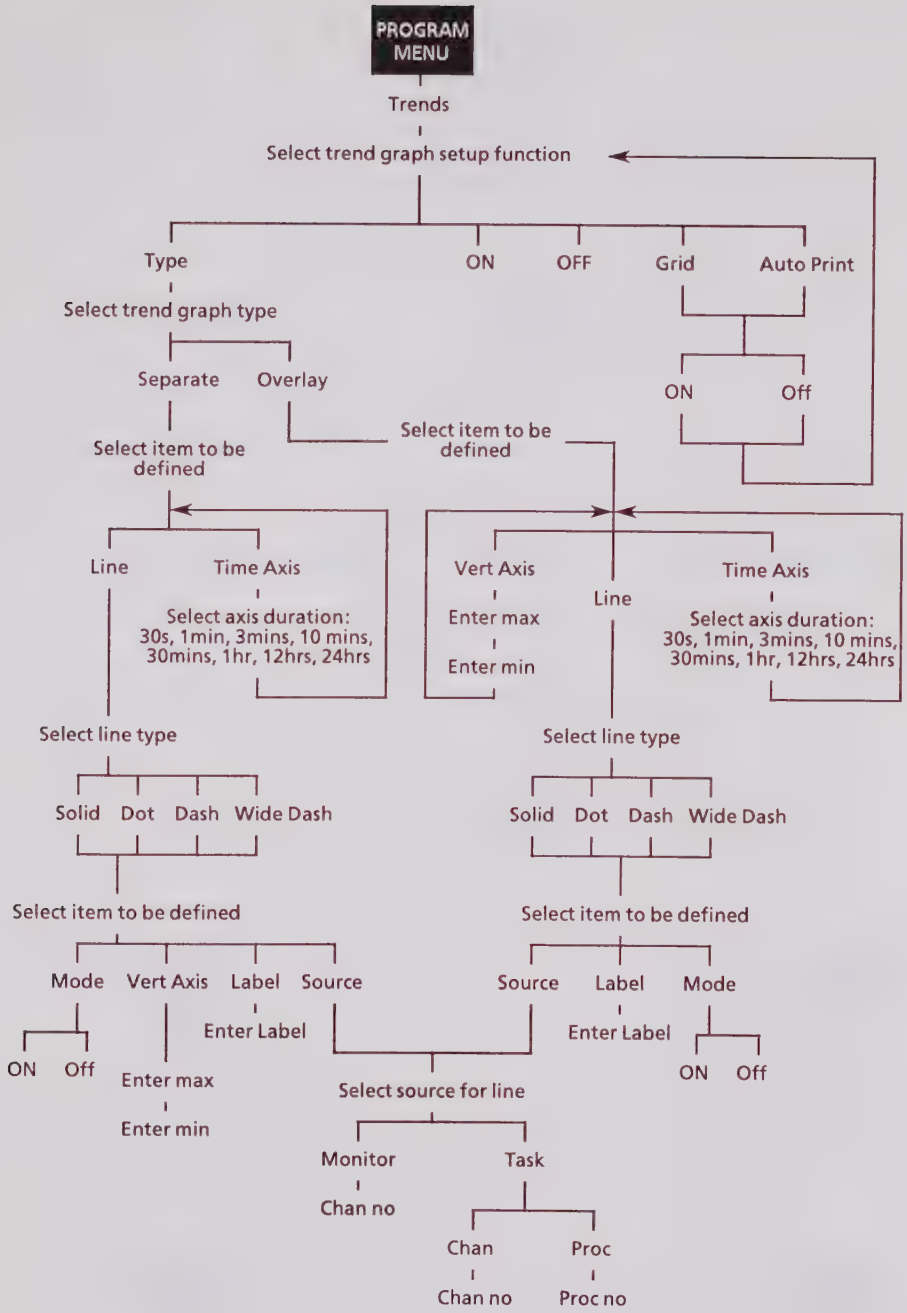


Fig 5.16 *PROGRAM menus for Trend graphs.*

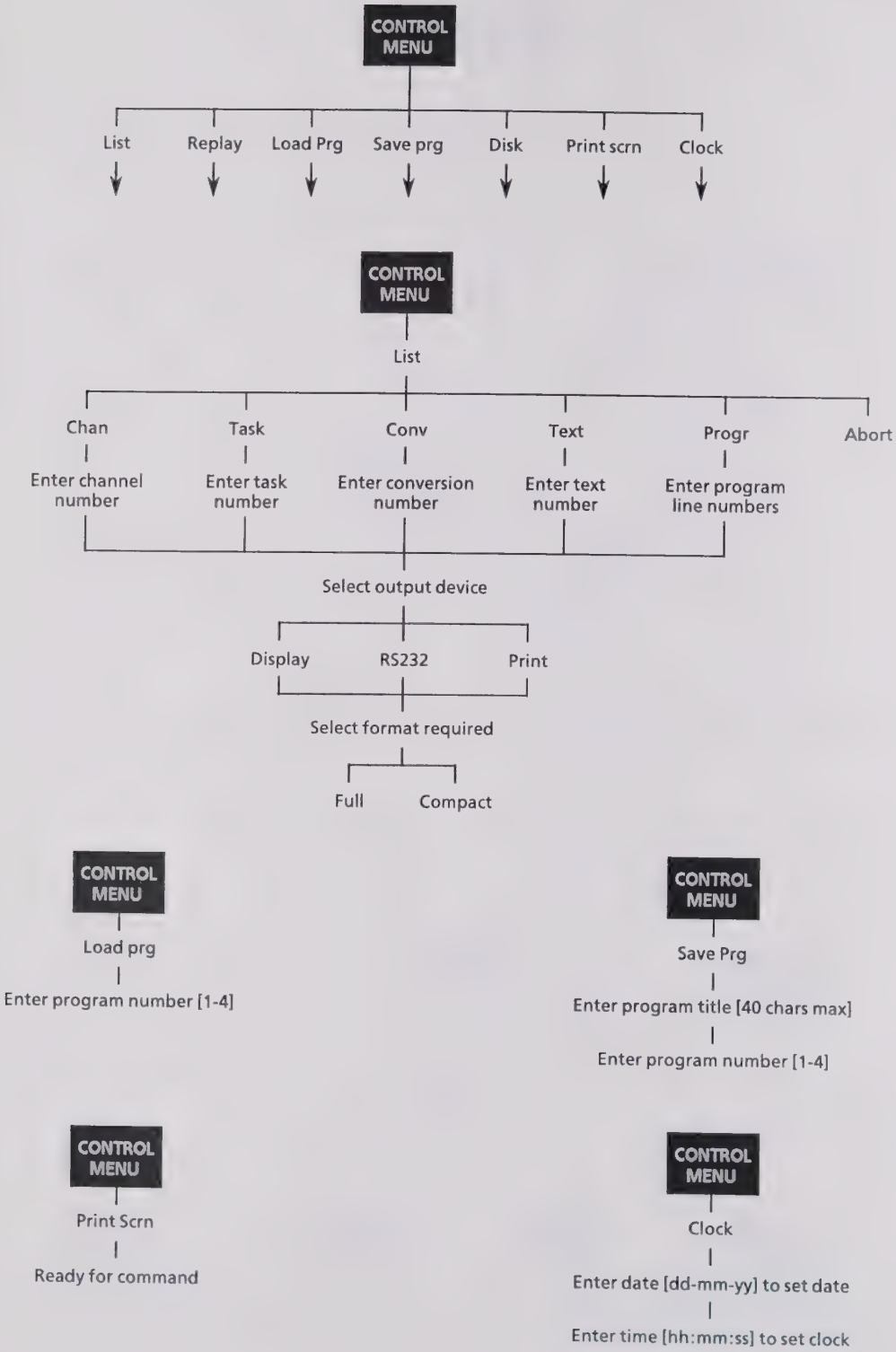


Fig 5.17 *CONTROL menus for list, load programs, save programs, print screen and clock.*

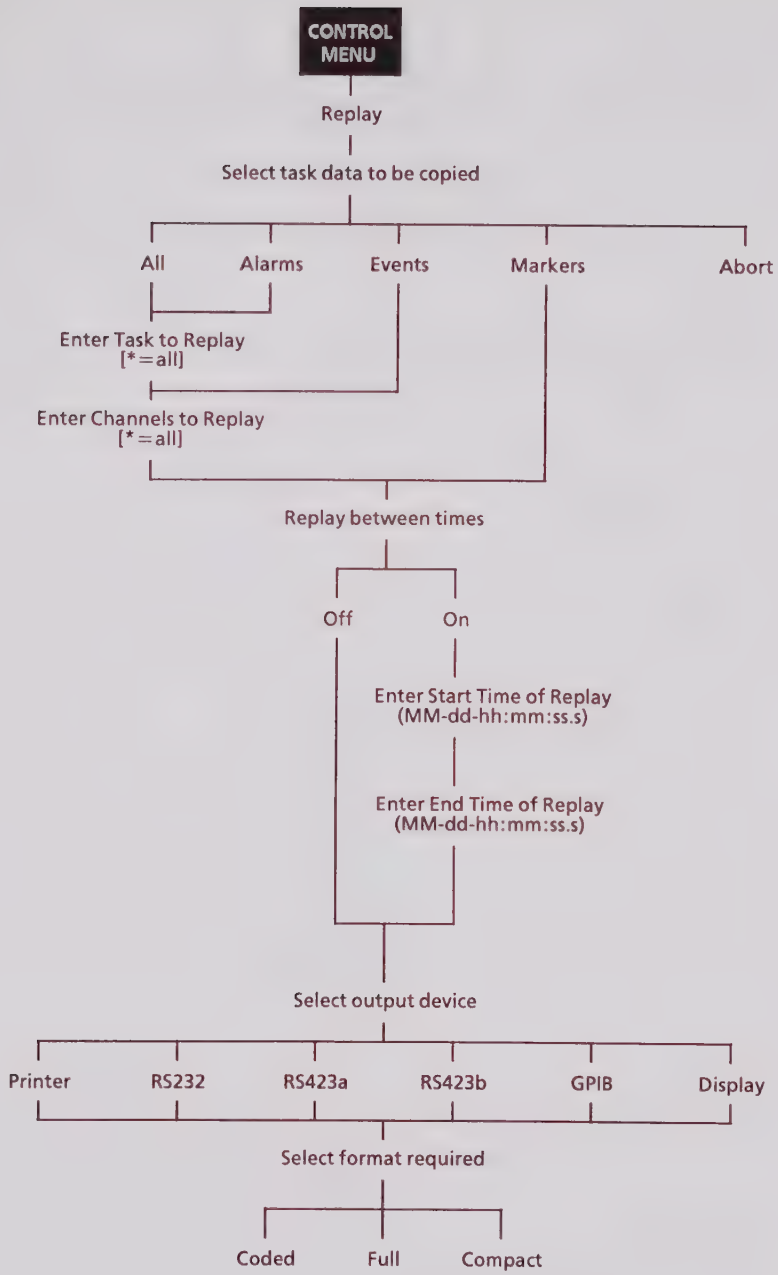


Fig 5.18 *CONTROL menus for replay.*

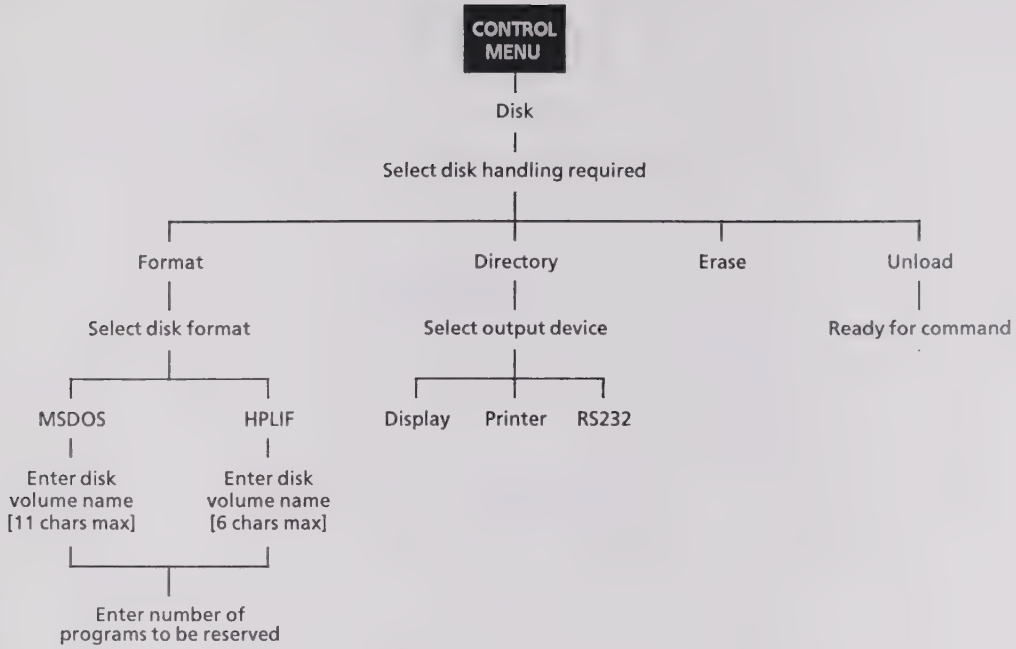


Fig 5.19 *CONTROL menus for disk.*

Chapter 6
Conversions and Alarms

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1 APPLICATION OF CONVERSIONS AND ALARMS

Conversions and alarms can be applied individually to any input channel, or group of channels. Conversions are always done first. The values and units derived from the conversion are then used for the alarm functions.

Conversions and alarms are always linked to a specific channel with the Channel Definition. Also, if a channel is included in several tasks, then any of these tasks can detect or reset the alarm, or output processed data for that channel. It is possible for the user to request a log of readings in alarm, or similarly of processed results.

Conversion constants and alarm levels can be entered as ordinary numbers when they are within the specified range (10^{-7} to 10^{7}). Numbers outside this range, but within the range 10^{-15} to 10^{15} should be entered in exponential form, e.g. to enter 37.5 million, enter 37.5 E6 (E6 implies $\times 10^{6}$).

2 CONVERSIONS

The 3535 automatically accommodates conversions for specific types of input. These include the results from the thermocouple or PRT channels, which are automatically output in °C (or °F) and the results from strain gage channels, which are automatically output in microstrain. By means of the Conversion Definition facility, the user can apply one of four types of mathematical conversion to any measured value:

- Scaling and offset (linear)
- Cubic polynomial
- Reciprocal
- Square root
- 4-20mA current transmitter

It is possible to store up to 600 conversion equations of mixed type. Each equation has a conversion number from 1 to 600, and is assigned to a specific channel (or group of channels) by entering the number in the appropriate part of the Channel Definition.

Numeric entry is limited to the first six significant figures. If the number entered is greater than 524,288 or less than 0.0039 then, when that number is recalled it will be displayed in exponential form with 3 significant figures. However, the full version of the original number (up to six figures) is retained in memory and is used in the calculations.

2.1 SCALE

Scale gives a linear, scaling and offset, conversion. Enter the constants m and c, and units for the scale equation:

$$y = mx + c \text{ units}$$

where m=scaling factor; c=offset; units=any characters (three max); x=measured value; y=conversion result.

The scale equation may be used, for example, to convert °C to °F. The 3535 measures temperature in °C, and so, by applying the equation

$$°F = \frac{9}{5}°C + 32$$

to the measured value, the temperature is obtained in °F.

Converting the above formula to the scale equation format:

y	=result, in °F,
m	$=9\div5=1.8$,
x	=measured temperature, in °C,
c	$=32$,
"units"	=FAR (abbreviation for Fahrenheit)

therefore, the scale equation $y=mx+c$ becomes

$$y=1.8x+32 \text{ FAR}$$

with a measured temperature of 15°C this equation becomes

$$y=1.8\times15+32=59 \text{ FAR}$$

The units in the above example are entered as 'FAR', this being an abbreviation for °F. All results from this Conversion will include 'FAR', thereby giving indication of the correct units. Depending on the application, any suitable units can be entered.

Note: This is simply an example. Results can be obtained in Fahrenheit by setting the instrument language to "American English".

2.2 POLYNOMIAL

This gives a cubic conversion of the form

$$y=ax^3+bx^2+cx+d \text{ units}$$

where a, b, c and d are constants; units=any characters (three max); x=measured value; y=conversion result.

Enter a, b, c, d and "units" to obtain a cubic conversion. To obtain a square-law conversion set a to zero.

2.3 RECIPROCAL

This gives a fractional conversion of the form

$$y=\frac{a}{x} \text{ units}$$

where a is a constant; x=measured value; units=any characters (three max); y=conversion result.

The reciprocal conversion could typically be used in a stress/strain calculation such as E=stress÷strain, where the strain, measured in microstrain (με), is the input from a strain gage channel.

2.4 SQUARE ROOT

This provides a square root conversion of the form

$$y = \sqrt{ax+b} \times c + d \text{ units}$$

where a, b, c and d are constants; x=measured value; units=any characters (three max); y=conversion result.

The Root conversion could typically be used to calculate flow rate, using the results from a differential pressure transducer. Alternatively, just the square root part of the equation can be used on its own ($\sqrt{x}$) by setting $a=1$, $b=0$, $c=1$, and $d=0$.

For values of x which yield a negative result for the equation ($ax + b$), the results will be invalid since the square root will be evaluated by negating the –ve sign.

2.5 4-20mA

A special scale conversion is provided for 4-20mA sensors, which provide a variable current output directly proportional to temperature, strain etc. This conversion should be applied to any channel using a 4-20mA sensor. (Energization for 4-20mA sensors is provided by the SI 35951D Transducer Energization Module, from a connector at the rear of the SI 3535 Data Logger.)

The values to be entered for 4-20mA conversion are a Lo value for the 4mA output of the sensor and a Hi value for the 20mA output. From these values the logger computes the slope and intersect of a conversion law, which is used in interpreting the intermediate values of the sensor output. See the example in Fig 6.1. The Hi and Lo values can be obtained either by experiment or from the manufacturer's data sheet.

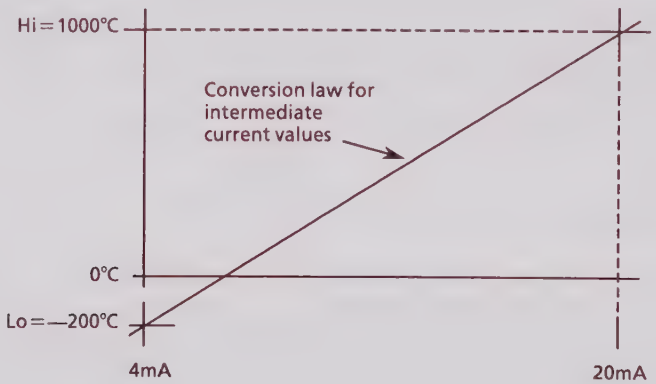

Fig 6.1 *Example of $y=mx+C$ law defined by 4-20mA facility.*

2.6 CHANGING UNITS

In the absence of a conversion being applied, all measurements output by the 3535 are accompanied by their respective units, ie, V, Ω, mA, μ strain, or °C (°F where American English is specified). The Conversion Definition facility permits the user to apply different engineering units, as required (eg. PSI, RPM, CMS, etc). When a Conversion Definition is applied to any measurements, the normal units output by the 3535 are cancelled (even if no units are specified in the Conversion). Units specified in a Conversion can consist of any characters, up to a maximum of three.

To enter units only, use a scale conversion (setting m to 1 and c to 0).

3 ALARMS

Alarms occur when measurements or converted results are compared with, and exceed pre-defined levels. Any combination of the following alarm actions is possible:

- The results are logged.
- Digital outputs are activated.
- Another task is triggered.

The following alarm states are defined:

- Limits.
- High Threshold.
- Low Threshold.
- Change.

Converted results from the input channels are compared with the alarm values to produce primary and secondary actions. If the results are found to be in an alarm state, any combination of the alarm actions described in Section 3.1 may be taken, as selected.

3.1 ALARM ACTIONS

Details of primary and secondary alarm actions are given in Sections 3.1.1 and 3.1.2.

3.1.1 Primary Alarm Actions

1. Alarm results only are logged. These are selected in the Task Definition, under data to be logged.

2. Alarm text is output. This is selected in the Channel Definition: enter the alarm text number. Text is defined in Text Definition.

3. One or two digital output channels produce a change of logic state. This is selected in the Channel Definition, under Alarm Outputs.

3.1.2 Secondary Alarm Actions

1. A task is aborted. This is selected in the Task Definition, "Abort Tasks" . It is permitted for a task to abort itself.

2. A task is triggered. This is selected in the Task Definition, "Trigger Tasks".

3.2 ALARM TYPES

For any analog channel, or bcd or digital counting channel, any one of four different types of alarm can be selected: *limits*, ↑ *threshold*, ↓ *threshold* and *change*. Each of these is described below.

It should be noted that alarm states of pattern match or pattern mismatch can be specified for digital status inputs, and that any event detected on a digital event input is automatically treated as an alarm.

3.2.1 Limits Alarm

High and low limits are entered as shown in Fig. 6.2. An alarm is generated if the measured result is greater than the high value or less than the low value.

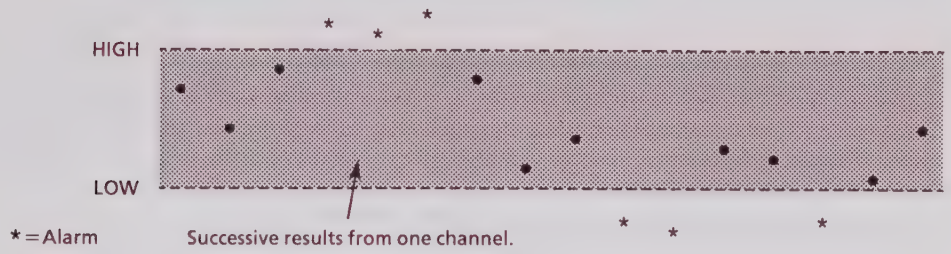

Fig 6.2 *Limits alarm.*

3.2.2 ↑ Upper Threshold Alarm

For upper threshold alarms a "deadband" is defined by an upper threshold limit and a low limit. The first reading above the threshold generates an alarm. Subsequent alarms are generated only when result readings cross the entire deadband in a positive direction (↑) i.e. previous readings were below the deadband. (See example in Fig 6.3.) This avoids repeated alarms when the user is interested only in a transition into a positive alarm state.

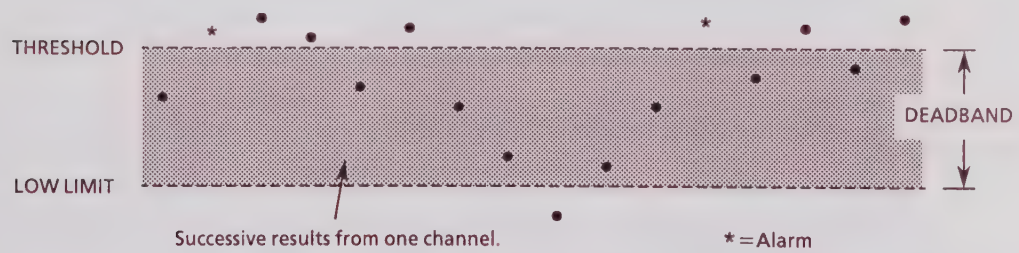

Fig 6.3 *Upper threshold alarm.*

3.2.3 ↓ Lower Threshold Alarm

For lower threshold alarms a "deadband" is defined by a lower threshold limit and a high limit. The first reading below the threshold generates an alarm. Subsequent alarms are generated only when result readings cross the entire deadband in a negative direction. (See example in Fig 6.4.) This avoids repeated alarms when the user is interested only in a transition into a negative alarm state.

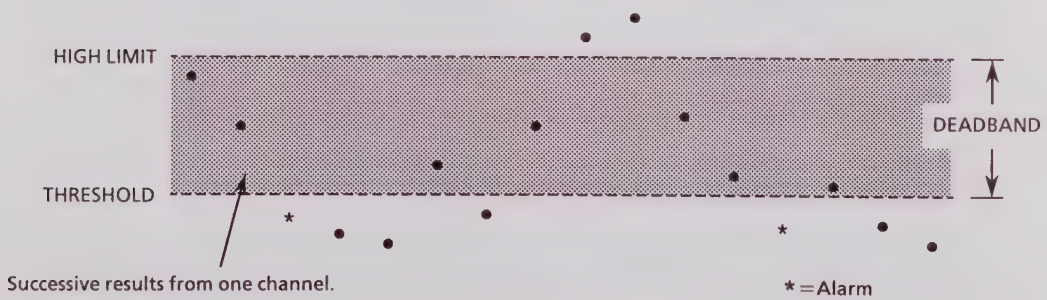

Fig 6.4 *Lower threshold alarm.*

3.2.4 Change Alarm

Threshold alarms ensure that alarms are logged only when readings have crossed a deadband into an upper, or lower, threshold. In contrast, the *change* alarm gives an indication that the *datum* of successive readings has moved up or down by more than a predefined amount.

A change alarm is set by entering the change value. The first result always generates an alarm, and the value of this result is defined as the datum level for observing changes. Following on from this, an alarm occurs only when the result is outside the datum ± change levels. When an alarm is generated, the datum moves to the value of the alarm result and subsequent readings are compared with the new datum ± change. Subsequent alarms cause the datum to adopt the new alarm value.

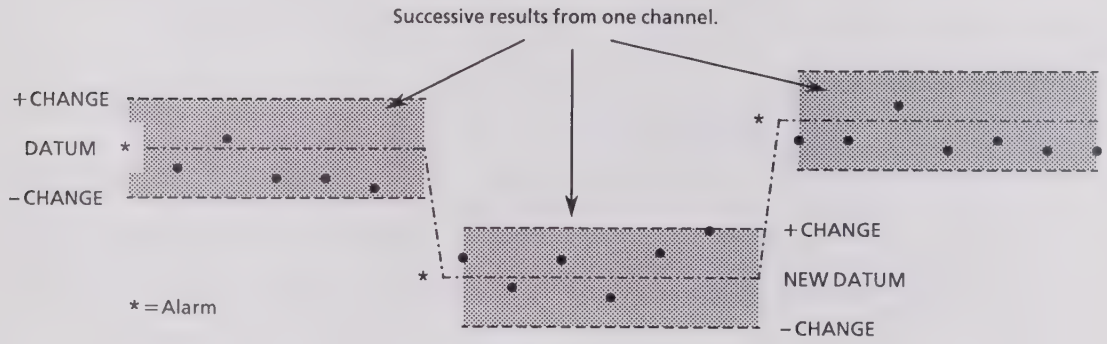

Fig 6.5 *Change alarm.*

3.2.5 Alarm Outputs

Any digital output channel, contained on a digital input/output module can be used as an alarm output. One, or two, alarm outputs can be assigned to an input channel or group of channels, and are referred to as 'Lo,Hi'. The Lo channel changes logic level when the result from an input measurement goes lower than a pre-defined limit; the Hi channel changes logic level when the result from an input measurement goes higher than a pre-defined limit. The alarm outputs can thus indicate that the input to which they are assigned has gone out of high or low limits.

The output channels are at Logic 0 in the non-alarm, state. When an alarm is detected, the relevant alarm output channel changes state from Logic 0 to Logic 1. (Logic 1 represents the conducting state of the output switch). The output remains at Logic 1 until the next non-alarm measurement is detected (refer to Table 6.1).

Table 6.1 Alarm States

Alarm State	Alarm Outputs	
	Lo Channel	Hi Channel
When <Low alarm state is detected.	Changes to logic "1".	
When >High alarm state is detected.		Changes to logic "1".

The Lo/Hi alarm channels that can be specified for each alarm type, and the resulting action of the alarm outputs, are listed in Table 6.2.

By default the digital outputs are reset to logic 0 when the instrument is halted. This can be altered using the "RD OF" command described in the Reference Manual.

Table 6.2 Action of Alarm Outputs

Alarm Type	Alarm Channels Applicable	Action of Alarm Outputs
Analog, Digital Counting, and BCD inputs only:		
High and Low limit	Hi and/or Lo	Hi channel goes to logic "1" when hi limit exceeded; Lo channel goes to logic "1" when Lo limit exceeded.
"↑" Threshold	Hi only	Hi channel goes to logic "1" when entire deadband is crossed in a positive direction.
"↓" Threshold	Lo only	Lo channel goes to logic "1" when entire deadband is crossed in a negative direction.
Change	Hi and Lo	Hi channel goes to logic "1" when a more positive change is detected. Lo channel goes to logic "1" when a more negative change is detected.
Digital Bit inputs only:		
Match/Mismatch	Hi and Lo	Hi and Lo channels go to logic "1" when match or mismatch detected.
Digital Event inputs only:		
Event (Hi to Lo)	Hi only	Hi channel goes to logic "1" for Lo to Hi event.
Event (Lo to Hi)	Lo only	Lo channel goes to logic "1" for Hi to Lo event.
Event (any transition)	Hi and Lo	Hi channel goes to logic "1" for Lo to Hi event; Lo channel goes to logic "1" for Hi to Lo event.

3.3 TYPICAL APPLICATIONS

The SI 3535 Data Logger provides control outputs for external plant equipment. In a simple application, alarm signal outputs could be used to switch devices on or off. Where a device uses a supply that can not be switched directly by the SI 3535, e.g. a 240V ac heater, a control relay is necessary.

The application shown in Fig 6.6 is that of a 240V ac heater that is switched on at a low temperature and switched off at a higher temperature. The temperature is continually monitored by an analog input channel, and each result is compared with Hi and Lo temperature limits. Two digital output channels are used to control the heater supply: the Lo alarm output switches the supply on and the Hi alarm output switches it off.

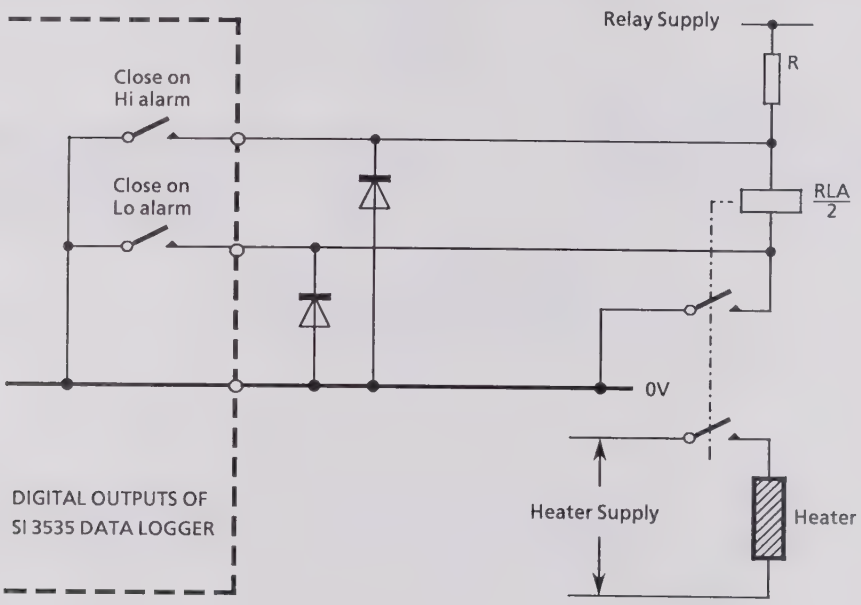

Fig 6.6 *Typical application of digital outputs.*

The digital outputs, shown in Fig 6.6 as simple switches, are actually field-effect transistors. These outputs are internally protected against excessive positive voltage, but it is good practice to include the two diodes shown for protection against negative transients. The value of resistor R depends on the voltage of the relay supply and it must limit the digital output current to less than 150 mA.

Notice the use of the relay hold-on contacts. These ensure that the relay remains energized when the Lo alarm switch, having brought in the heater, opens again for the first temperature measurement that is above the low limit.

When the Hi temperature limit is reached the Hi alarm switch is activated to short the relay supply to 0V: the heater is thus switched off. When the temperature falls below the Lo limit the Lo alarm switches the heater on again. The sequence thus continues.

The use of the outputs as simple switches has the advantage that various devices, each with its own supply, can be controlled. The 0V return must be common to all devices for any one output module, but may float at up to ± 100V from earth (the SI 3535 chassis).

3.3.1 Logic Outputs

As an alternative to the simple switching of external devices, the digital output of the SI 3535 Data Logger can be set to provide logic level outputs. The simplified circuits for this are set by links in the SI 35302B Digital Input/OutputModule. (See Chapter 9 for details.)

To interface directly with plant logic operating at 24V (or (12V) the output switches of the SI 35302B may be powered from the plant logic supply. Although the maximum voltage specified for the digital outputs is 25V, no difficulty should be experienced with the excursions to 27V, or even 30V, experienced with conventional logic.

To control TTL logic, the digital outputs can be powered either from an external +5V supply or from the internal +5V supply of the SI 35302B Module. Whichever supply is used, however, should be common to all outputs from the same module.

The use of alarm outputs in the ways outlined above provides external action that results directly from a measurement, a status, or an event, occurring on a specific channel. In the case of measurements, high or low limits, thresholds, or a change, can determine the conditions for which the output occurs. Thus, within one Task, alarm outputs associated with various channels can cause external action dependent on the results from those channels.

Chapter 7
Output Formats

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Table

7.1 Output Format Availability 7.3

1 OUTPUT FORMATS

Messages and measured results are output by the logger to any device selected for output in Task Definition. The output devices include the display, printer and disk drive that are integral to the logger, and any devices connected to the GPIB, RS232 or RS422 interfaces. In addition to selecting the output device, you may also select the output format. The formats available for each output device are shown in Table 7.1.

Table 7.1 Output Format Availability

Output Device	Formats Available			
	Full	Compact	Coded	Binary
Display	●	●		
Printer	●	●		
Disk	●	●	●	
GPIB	●	●	●	●
RS232	●	●	●	●
RS422a,b	●	●	●	

●=format available.

Full Format contains all information, including text messages and results. This information is obtained at the expense of storage space on print roll, disk, etc, and consists of 40-character strings.

Compact Format contains full numeric information, i.e. results etc, but excludes text. Each result consists of a 20-character string and therefore requires less storage and recording space than full format.

Full format and compact format are intended for readable outputs on printers or displays, with an eighty character line length. With these devices, full format gives two results per line, whilst compact format gives four.

For the same output format (full or compact) the arrangement of measurement results and messages on the integral printer and display ("text" content) and any external printer or display is exactly the same. The one exception to this is obtained when "normal" format is selected for the integral printer, in which case the results are printed the right way up (as viewed from the front of the logger) but in reverse chronological order.

Coded Format is intended primarily for recording data on the logger disk, but data thus recorded may be saved to any other device. Each result in coded format is a binary number encoded into a string of ten printable ASCII characters. Texts are not output in coded form. Coded format takes up minimum disk space and therefore permits the maximum number of results to be recorded. Results recorded in coded format are normally replayed only in the logger.

Binary Format is the most convenient way of exporting data (via the GPIB or the RS 232 or RS 422a,b serial interface) for subsequent processing by computer. (Binary format needs no complex decoding, prior to being used by the computer.)

Data in binary format can not be output to the display, printer, fast serial output (RS422a or b) or disk; neither can it be read from a disk.

Working descriptions of full format and compact format results and messages are given in Section 2, which follows. Detailed descriptions of all formats are given in the Reference Manual.

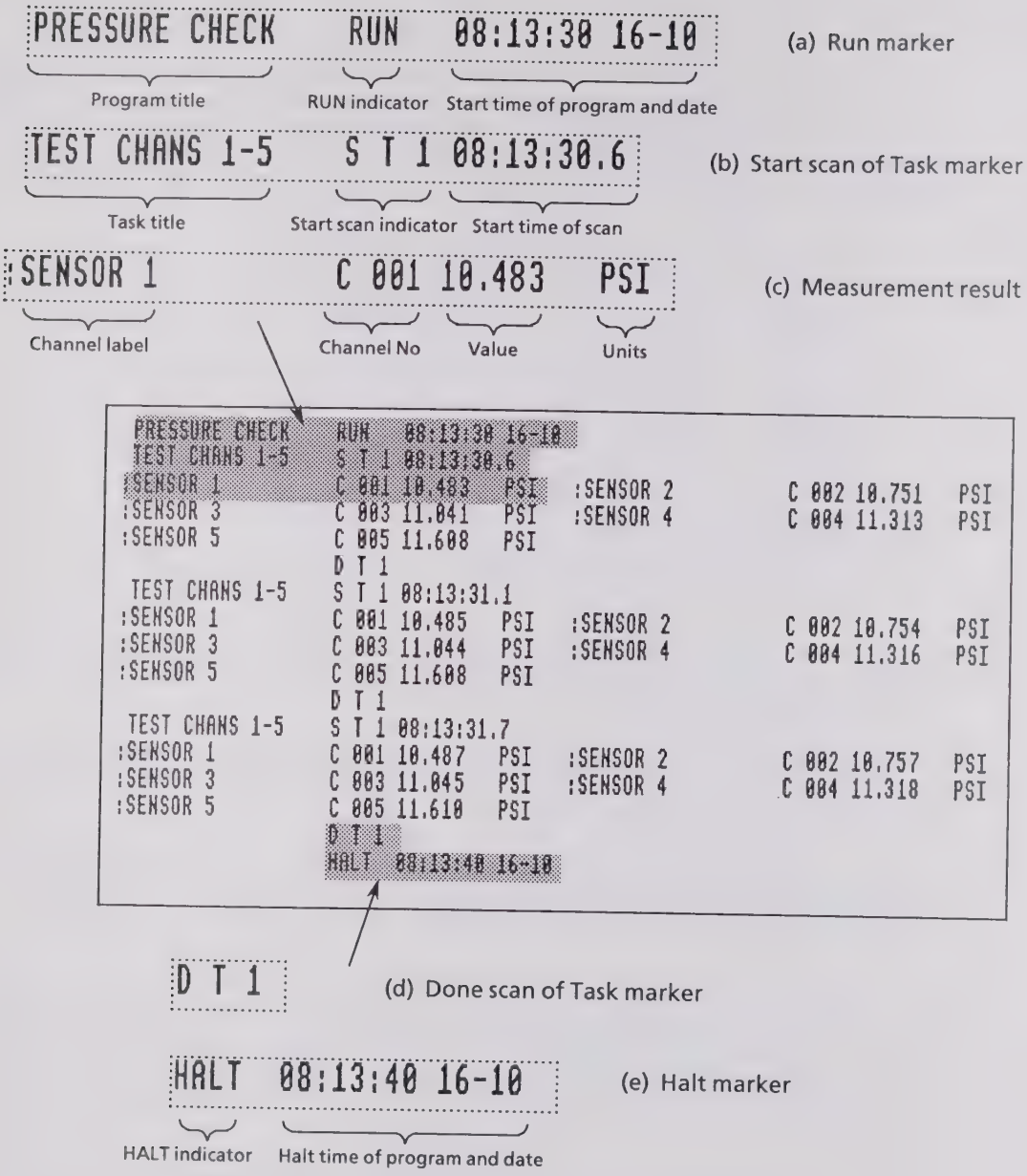
PRESSURE CHECK RUN 08:13:30 16-10
Program title
RUN indicator
Start time of program and date
(a) Run marker
TEST CHANS 1-5 S T 1 08:13:30.6
Task title
Start scan indicator
Start time of scan
(b) Start scan of Task marker
:SENSOR 1 C 001 10.483 PSI
Channel label
Channel No
Value
Units
(c) Measurement result
PRESSURE CHECK RUN 08:13:30 16-10
TEST CHANS 1-5 S T 1 08:13:30.6
:SENSOR 1 C 001 10.483 PSI :SENSOR 2 C 002 10.751 PSI
:SENSOR 3 C 003 11.041 PSI :SENSOR 4 C 004 11.313 PSI
:SENSOR 5 C 005 11.608 PSI
D T 1
TEST CHANS 1-5 S T 1 08:13:31.1
:SENSOR 1 C 001 10.485 PSI :SENSOR 2 C 002 10.754 PSI
:SENSOR 3 C 003 11.044 PSI :SENSOR 4 C 004 11.316 PSI
:SENSOR 5 C 005 11.608 PSI
D T 1
TEST CHANS 1-5 S T 1 08:13:31.7
:SENSOR 1 C 001 10.487 PSI :SENSOR 2 C 002 10.757 PSI
:SENSOR 3 C 003 11.045 PSI :SENSOR 4 C 004 11.318 PSI
:SENSOR 5 C 005 11.610 PSI
D T 1
HALT 08:13:40 16-10
D T 1
(d) Done scan of Task marker
HALT 08:13:40 16-10
(e) Halt marker
HALT indicator
Halt time of program and date

Fig 7.1 *Example of full format output, with headers.*

```
 PRESSURE CHECK    RUN   09:08:10 16-10
:SENSOR 1          C 001 4.1045   PSI   :SENSOR 2          C 002-5.1055   PSI
:SENSOR 3          C 003-1.0000   PSI   :SENSOR 4          C 004 0.0000   PSI
:SENSOR 5          C 005-1.0000   PSI   :SENSOR 1          C 001 4.4050   PSI
:SENSOR 2          C 002-4.3048   PSI   :SENSOR 3          C 003-1.2000   PSI
:SENSOR 4          C 004 0.0000   PSI   :SENSOR 5          C 005-1.2500   PSI
:SENSOR 1          C 001 4.6048   PSI   :SENSOR 2          C 002-0.3043   PSI
:SENSOR 3          C 003-1.3000   PSI   :SENSOR 4          C 004 0.0000   PSI
                   HALT  09:08:16 16-10
```

Fig 7.2 *Example of full format output, without headers.*

2 OUTPUT FORMAT EXAMPLES

This section contains some simple examples of outputs in full and compact format. To give you a working knowledge of these formats, salient features, such as RUN markers and HALT markers are pointed out, and the interpretation of the measurement results is explained. **Full details are given in the SI 3535 Reference Manual, Chap. 5.**

2.1 FULL FORMAT RESULTS

The full format examples show a scan of channels (1-5). A conversion has been applied to all channels, giving results in lbs per square inch (PSI). Each result has a text label attached, which indicates a Sensor number.

Full format outputs, with and without headers, are shown in Figs 7.1 and 7.2. Note that formats without headers may be selected only with the remote command TAsk *n MArkers NOne (which can also be entered from the front panel keypad). For details of the SI 3535 remote commands see the SI 3535 Reference Manual.*

Referring to Fig 7.1, the significance of the various parts of a full format output, with headers, is as follows:

(a) ***Run Marker***. A run marker always appears at the beginning of an output block, with or without a program title, when the logger enters the RUN state. A program title is included when this has been entered prior to copying the program to disk. The program title in the present example is "PRESSURE CHECK". A program title can contain up to forty characters, but for any device other than disk the title is curtailed to eighteen characters maximum.

Following the program title (when entered) "RUN" indicates the start of a program and following this is the program start time and date. In the example shown in Fig 7.1 the time is 08:13 and 30.6 seconds, whilst the date is the 16th of October (16–10 = *day–month*). If American English is selected the date format changes automatically to *month–day*, which, in the present example, would give a date of 10–16.

(b) ***Start scan (of Task) marker*** —ST*n*. (This is also known as a "start scan marker" or "header".) An ST*n* marker indicates the beginning of a scan for a particular task, and is included in the output when "headers on" is selected for the task in question. In the present example, "ST1" indicates the start of a scan for Task 1. "Headers on" is the default state of the logger output.

An ST*n* marker can contain a task title of up to eighteen characters. The title is entered, after the task number, during task definition. In the highlighted example in Fig 7.1 the title of Task 1 is "TEST CHANS 1-5". Following this, "ST1 08:13:30.6" (*hh:mm:ss.s*) indicates that a Task 1 scan started at 08:13 and 30.6 seconds.

(c) ***Measurement Results.*** Measurement results in full format can have either of two channel labels attached, one for normal results and the other for alarm results. The text for the channel labels is entered against a text number, under "Text" in the Program menu. Up to eighteen characters are allowed for each label. During channel definition, the required labels for each channel are specified by entering the appropriate text numbers. The label for the highlighted result in Fig 7.1 is "SENSOR 1", which indicates the source of the input signal.

The remainder of the result consists of the channel number, e.g. "C 001", the actual value of the result, e.g."10.483", and the units, e.g. "PSI" (lbs/sq in). (Note that the "PSI" units are entered in the Conversion program menu.) For a monitored result, the "C" which precedes the channel number is replaced automatically by an "M";

for a processed result the "C" is replaced by a "P" and a period appears at the end of the result. If a processed result overwrites a channel result then the "C" remains.

For an alarm result the colon (:) at the beginning is replaced automatically by an exclamation mark (!) the alarm label (if specified) replaces the normal label, and an alarm indicator character appears after the units. (See Section 2.3 in this chapter.)

(d) ***Done scan (of Task) marker*** —DT*n*. (This is also known as an "end of scan marker", and is included with the STn marker for header selection.) A DT*n* *marker indicates the end of a scan and is included in the output when "headers on" is selected. (See description of STn* marker above.)

In the example shown in Fig 7.1 "DT1" appears whenever a scan ends for Task 1. No title or time information is given.

(e) ***Halt Marker.*** A halt marker always appears at the end of an output block, when the logger enters the HALT state. Following the "HALT" legend, is the time and date at which the HALT state was entered. The format of the time and date is the same as for the run marker.

In the example of full format output without headers (see Fig 7.2) note that the results are not separated with respect to individual scans but are presented in one continuous block.

2.2 COMPACT FORMAT RESULTS

In compact format the output contains numerical information only: no text. Therefore the results are output faster, and you get twice as many in the same area of print or display as with full format.

Compact format output contains four results per line.

Examples of compact format results, with and without headers are shown in Figs 7.3 and 7.4.

```
RUN   09:14:04 16-10
S T 1 09:14:04.6
C 001 2.1041   PSI  C 002-2.1056   PSI  C 003-2.0000   PSI  C 004 0.0000   PSI
C 005-0.0005   PSI
D T 1
S T 1 09:14:04.8
C 001 2.1048   PSI  C 002-2.1051   PSI  C 003-2.0000   PSI  C 004-0.0006   PSI
C 005 0.1000   PSI
D T 1
HALT  09:14:10 16-10
```

Fig 7.3 *Compact format output, with headers.*

```
RUN   09:12:03 16-10
C 001 2.1042   PSI  C 002-2.1053   PSI  C 003-2.0000   PSI  C 004 0.0000   PSI
C 005 0.0000   PSI  C 001 2.1048   PSI  C 002-2.1043   PSI  C 003-2.0020   PSI
C 004 0.0000   PSI  C 005 0.0000   PSI  C 001 2.1046   PSI  C 002-2.1047   PSI
HALT  09:12:07 16-10
```

Fig 7.4 *Compact format output, without headers.*

2.3 ALARMS AND PROCESS OUTPUT

The full format example in Fig 7.5 contains alarm and processing information. Each channel has two texts applied: non-alarm text="SENSOR *n*"; alarm text="ALARM SENSOR *n*"; *n* is the channel number.

```
 PRESSURE CHECK    RUN   09:52:59 16-10
 TEST CHANS 1-5    S T 1 09:52:59.6
!ALARM SENSOR 1    C 001 14.02    PSI>  !ALARM SENSOR 2    C 002-1.107    PSI<
:SENSOR 3          C 003 10.483   PSI   !ALARM SENSOR 4    C 004 20.00    PSI>. <-- a.
:SENSOR 5          C 005-8.627E-5 PSI . :                  P 106-1.537E-5 PSI . <-- b.
                   D T 1
                   HALT  09:53:03 16-10
```

Fig 7.5 *Alarm and process output.*

In Fig 7.5 note the alarm channels 1, 2, and 4. For each of these the result is preceded by an exclamation mark (rather than a colon) and the alarm text is present. On Channels 1 and 4 the ">" symbol indicates that the result is greater the high alarm limit, whilst on Channel 2 the "<" symbol indicates that the result is less than the low alarm limit.

Processed results can be made apparent in two ways, depending on the relationship between the result and a specific channel. If a processed result overwrites a channel result then the result retains the channel identity, but has a full stop at the end. An example of this is shown in Fig 7.5 (arrowed result a.). Here the process has multiplied the original result (stored as variable C4) by 10 and has overwritten this result by the new value. However, if a processed result is unrelated to any one channel then this result is identified by a process number, rather than a channel number. An example of this is shown in Fig 7.5 (arrowed result b.) which is identified as process result "P 106".

2.4 EVENT OUTPUT

The example in Fig 7.6 shows an event output. An event task "MONITOR CONTACTS" has been programmed to monitor a group of switch contacts through event (E) channels 81, 82, 83, 84 and 85. Each channel is set to respond to a Hi to Lo transition, or a Lo to Hi transition, or both ("any").

```
 MONITOR CONTACTS  RUN   17:05:49 06-02
:CONTACTS CLOSED   E L081 17:06:11.678
!CONTACTS OPEN     E H081 17:06:18.334
:CONTACTS CLOSED   E L082 17:06:24.839
!CONTACTS OPEN     E H083 17:06:45.240
:CONTACTS CLOSED   E L084 17:06:50.410
!CONTACTS OPEN     E H084 17:06:56.516
:CONTACTS CLOSED   E L085 17:07:03.388
                   HALT  17:09:37 06-02
```

Fig 7.6 *Event channel output.*

The task is being used to detect the movement of a switch contact, and two texts have been applied to each event channel in order to indicate contact open/contact closed. The texts have been defined as follows:

Non alarm text= CONTACT CLOSED (Lo input=Hi-to-Lo transition event)
Alarm text= CONTACT OPEN (Hi input=Lo-to-Hi transition event)

Note that although text is referred to as non-alarm and alarm, all events are regarded by the logger as alarms. This is significant where tasks are triggered by alarm states.

2.5 LISTINGS

Using the LIST facility, a listing of any Channel, Conversion, Text Definitions, Task or Program can be output, as shown in the examples in Fig 7.7.

Channel Definition
(for Channel 001)

```
--------------------CHANNEL  001
measurement Volts
 DC
conversion 1
alarm Limits
high  0.500000
low  0.500000
o/p 000,000
analogue o/p 0
text 1
alarm text 11
```

Conversion Definition
(for Conversion 001)

```
--------------------CONVERSION  001
type Scale
m;c  1.00000, 0
units PSI


--------------------CONVERSION  013
type Polyn
a;b;c;d  5.00000, 4.00000, 3.00000, 2.00000
units PSI
```

Text Definition
(for text 1-5 and 012)

```
--------------------TEXT  001
text SENSOR 1
--------------------TEXT  002
text SENSOR 2
--------------------TEXT  003
text SENSOR 3
--------------------TEXT  004
text SENSOR 4
--------------------TEXT  005
text SENSOR 5


--------------------TEXT  012
text ALARM SENSOR 2
```

Task Definition
(for Task 2)

```
--------------------TASK  001
title TEST CHANS 1-5
function Scan
trigger Timer
delay 00-00:00:00.0
scans 1
scan Continuous
channels 001-005
rate 500/s
processing On
data to be logged All
header Always
output device Printer
format Full
tasks triggered 0
tasks aborted 0
```

Program Listing
(for Task 2)

```
2000 MEAN;20;"MEAN";1;"VDC"
2001 DEV;20;"SD";1
2002 N=N+1
2003 FOR I=1 TO 20
2004 MEAN(I)=MEAN(I)+C(I)**2
2005 DEV(I)=DEV(I)+C(I)**2
2006 NEXT
2007 IF N=10 THEN
2008 FOR I=1 TO 20
2009 DEV(I)=MEAN(I)*MEAN(I)/N-DEV(I)
2010 DEV(I)=SQR(ABS(DEV(I)/N))
2011 MEAN(I)=MEAN(I)/N
2012 PRINT MEAN(I),DEV(I)
2013 MEAN(I)=0
2014 DEV(I)=0
2015 NEXT
2016 N=0
2017 ENDIF
```

Fig 7.7 *Definition listing samples.*

Chapter 8
Disk Drive

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1 MAIN FEATURES

A disk drive is incorporated in the SI3535D and SI3535G units. Information is recorded on a 3.5 inch double-sided, double-density (720k) floppy disk, with 80 tracks/side. The floppy disk drive does not support high density disks. However, high density disks can be used, though not preferred, if the disk-identity hole (on the opposite side to the write-protect hole) is taped over. If an error occurs when using the disk drive check that you haven't accidentally used a high density disk.

The disk can be formatted to either of two standards: IBM MS-DOS (from version 3.2) and HP-LIF. On a single disk, MS-DOS format allows the storage of up to 720 kbytes of information, with 9 sectors/track and 512 bytes/sector: HP-LIF format allows the storage of 616 kbytes, with 77 tracks, 16 sectors/track and 256 bytes/sector.

This information is in the form of "records" or "lines of text". Each record occupies the same space on disk, irrespective of content, but the size of this space depends on the format chosen.

The disk can be set for *write enabled* or *write-protected* by means of a Write-Protect switch located on the disk. When the disk is write enabled data can either be written to it or read from it. When the disk is write-protected, however, no data can be written onto the disk, thus protecting the data already recorded, but the recorded data can be replayed from the disk. For information on the disk drive and the disk write-protect switch, refer to Section 3 on the next page.

RECORD functions:

- FORMAT disk: prepares disk with a standard format, either MSDOS (from version 3.2) or HP-LIF.
- SAVE program: program in memory is stored (this includes any initialised parameters, such as unstrained gage measurements.
- LOG data: measurements are taken and saved on disk.
- ERASE data: measurements are erased.

REPLAY functions:

- DIRECTORY: a list of program numbers and names is output.
- LOAD programs: a stored program is output to memory.
- REPLAY logged data: specified stored data is output to an external device.

2 RESTRICTIONS

Restrictions on the use of disks in the SI 3535 floppy-disk drive are as follows:

(a) **DISKS MUST BE FORMATTED IN THE SI 3535.**

(b) Only the SI3535 can write to the disk.

NOTE: If a disk error occurs during RUN then the error is reported and the logger HALTED.

3 EJECTING AND INSERTING A DISK

To eject and re-insert a disk, proceed as follows:

1. Check the operating state of the SI 3535 Data Logger. It should be:

(a) in the Halt mode, or

(b) in the Run mode, but set to PAUSE due to the disk being completely filled, or

(c) in the Pause state, selected manually with the the disk Unload facility. (Press the PAUSE key, wait for the message "Ready for command", and then press the disk Unload key.)

2. Carefully pull down the hinged cover in front of the disk drive.

3. **Ensure that the red record indicator on the disk drive is not illuminated.** Then press the disk eject button (Fig 8.1) to eject the disk.

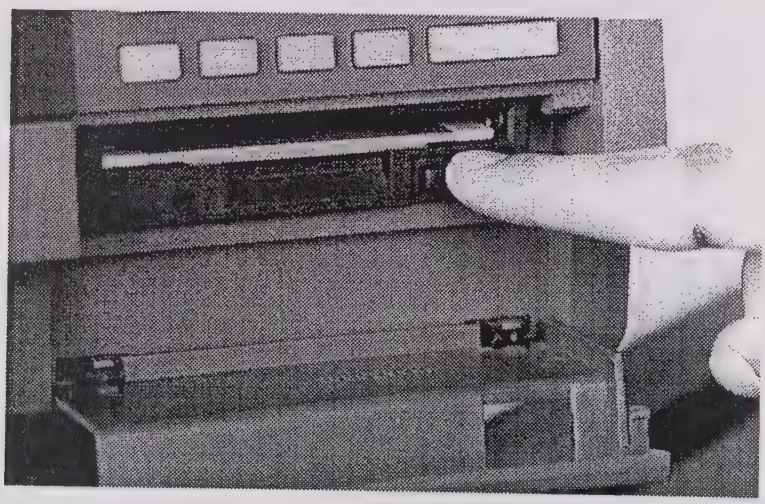

Fig 8.1 *Pressing the disk eject button.*

4. Before inserting a new disk check that the write-protect tab (Fig 8.2) on the disk is set as required. If the disk to be inserted is replacing a full disk (with the logger in the Pause state) then it should be ready-formatted.

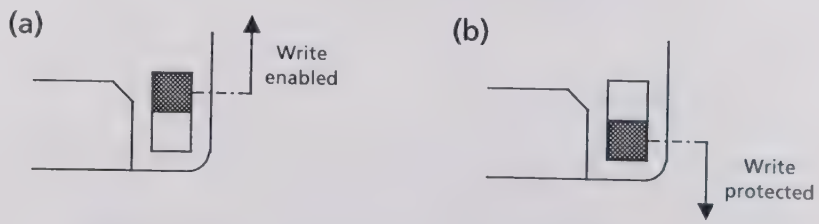

Fig 8.2 *Write protect tab (on underside of disk).*

5. To insert the disk, push it into the disk drive aperture until it clicks down into place. Then swing the disk drive front cover back into position.

4 RECORDING MODES

Data logged by the SI 3535 can be recorded on disk in either a *normal* or a *cyclic* mode.

4.1 NORMAL MODE

In the normal mode, data is recorded on the disk until the disk is full. The logger then goes into the pause state: recording to disk stops; a message indicating "Disk full" is automatically displayed, with an audible warning; and data that would otherwise have been output to the disk is stored temporarily in a 5000 result buffer.

The number of results stored depends on the scan mode: *continuous* or *interval*. With continuous scanning, channel measurements continue to the end of the scan and are stored in the buffer. With interval scanning, however, scanning continues until the buffer is full (should this happen before a new disk is inserted) and then stops immediately (possibly part way through a scan).

To insert a new disk (with the logger in the Pause state) first press the Unload key (under "Disk" in the CONTROL menu); then eject the full disk and insert a ready-formatted empty one. The full procedure is described in Section 3. Once a new disk is inserted you may press the PAUSE key to deselect the Pause state. Recording to disk is then resumed.

Should you suspect that a disk is nearly full and wish to insert a new disk prior to leaving the logger running, then you can press the PAUSE key to select the Pause state manually. Once "Ready for command" is displayed, the Unload key may be pressed and a ready-formatted empty disk inserted. (See Section 3.)

4.2 CYCLIC MODE

In the cyclic mode, data continues to be recorded on the disk when the disk is full. Data already recorded is overwritten by newly-logged data, progressing from the earliest recorded data to the more recent. This ensures that the disk always contains a record of the latest data.

The PAUSE facility can also be used with disks recordings made in the cyclic mode, possibly to remove a disk containing a required program recording.

5 SOLVING SLAVE UNIT MEMORY PROBLEMS

Some previously unassigned memory is automatically allocated to slave units that are attached to the SI 3535. Hence, it is possible that there may not be sufficient memory to accommodate certain programs recorded on disk. If an attempt is made to load such a program, one of two things could happen:

(a) The program loads correctly, but processing information is disregarded. To avoid rewriting the entire program, disconnect the slave units. Check that the program now loads correctly, allowing it to be edited for a smaller memory size.

(b) The complete program loads correctly, but, when RUN is entered, an error is displayed. This indicates that there is insufficient memory to accommodate the processing program variables. However, since the whole program is now in memory, it can be edited down to reduce its length without disconnecting the slave units.

6 RECORDED PROGRAMS

A program consists of setting-up information, which is entered using the front panel controls (PROGRAM menu) or a remote terminal. Each program can contain up to eight tasks. The memory in the SI 3535 can contain one program, but several programs can be recorded on one disk, i.e. four in MS-DOS format and three in HP-LIF format.

Because of the way in which programs are stored on the disk, it is essential to allocate spaces for them. Each program consists of 173 kbytes, and occupies approximately 24% of the total storage space on the disk. The number of program spaces allocated affects the number of results that can be stored on the same disk. Section 7.3 gives the details.

6.1 AUTOMATIC PROGRAM RELOADING

In the event of the SI 3535 memory being corrupted during a power failure, i.e. when the internal back-up battery is exhausted, Program 1 can be automatically loaded into memory when power is restored. This provides a safeguard against total loss of a program, and allows the SI 3535 to re-start logging routines immediately the program is reloaded.

The automatic loading of Program 1 (Program Booting) is conditional on the setting of the "Boot" switch on the Controller. (See Chapter 3, Section 4.2.) If this facility is used, it is important to save the appropriate program as "Program 1", because it is only this program that can be loaded automatically. This program is also loaded automatically at initial switch-on of the logger.

7 RECORDED DATA

Measurements are recorded in 8-bit ASCII, in one of three formats: Coded, Compact and Full. The approximate number of results which can be recorded on disk for each of these formats is specified in Section 7.3.

The speed at which data is written to disk can be up to 500 channels/second, depending on the format and the module used.

7.1 CODED FORMAT

Coded Format gives the most economical use of disk space and consists of specially encoded ASCII characters. When the data is replayed from disk it is decoded and reconstituted by the logger. The program used for saving the data must be reloaded to replay Coded data, in which case all the information normally present in Full format (text messages etc) can be output. Therefore, disks recorded in Coded format are normally read by the SI 3535, but they can be replayed on other read stations if suitable decoding is applied. Details of the coded format are given in the SI 3535 Reference Manual.

Coded results should not be replayed with time tagging turned on. When recorded these results do not have a time tag attached. Therefore, if the results are replayed in full format, with time tagging turned on, the logger does indeed produce time tags, but they are meaningless.

7.2 COMPACT AND FULL FORMAT

Disks written in Compact or Full format can be replayed on any suitable read station without the need for decoding. Refer to application note P/3531/01 for converting compact format data to lotus DIF format.

7.3 RESULT CAPACITY OF THE DISK

The number of results that can be stored on a disk depends on:

(a) the standard format used, i.e. HP-LIF or MS-DOS,

(b) the number of program slots allocated,

(c) the output format used: full, compact, or coded.

Table 8.1 lists the *approximate* number of results that can be stored in accordance with items (a) (b) and (c) above.

Table 8.1 Result Capacity of Disk against Standard Format, Programs Allocated and Output Format

HP-LIF				MS-DOS			
Program Slots Allocated	Output Format			Program Slots Allocated	Output Format		
	Full	Compact	Coded		Full	Compact	Coded
0	14,995	28,625	52,480	0	17,375	33,175	60,820
1	10,782	20,584	37,738	1	13,165	25,134	46,080
2	6,564	12,532	22,976	2	8,947	17,082	31,317
3	2,346	4,480	8,213	3	4,729	9,029	16,554
-	-	-	-	4	512	977	1,792

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Data Acquisition Modules

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1 INTRODUCTION

This Chapter provides a brief technical description at user level of the following SI 3535 modules:

- Reed-Relay Selector (SI 35301A) Solid-State Selector (SI 35301B) and High Voltage Solid-State Selector (SI 35351C).
- Transducer Energization Module (SI 35351D).
- Event-Status Input Module (SI 35302A).
- Digital Input-Output Module (SI 35302B).
- Counter Timer Module (SI 35302C).
- Analog Output Module (SI 35301E).

By configuring the SI 3535 with a selection of these modules, up to 200 channels can be provided for data acquisition. Careful consideration must be given to which types of transducer to use, in conjunction with which type of module.

1.1 TYPES OF MEASUREMENT

By selection of the appropriate modules, the SI 3535 can be configured to accept both analogue and digital input signals derived from a variety of sensors, transducers and other external sources. Analogue signals are handled by the Reed-Relay, Solid State and High Voltage Solid State (HVSS) Selectors, each input in turn being connected to the measurement circuit, by means of switches on the appropriate selector module.

Switching organisation is the same for all types of analog selector, each module having a capacity of 20 channels for 3-pole connections, or 10 channels for 6-poles. (Both 3-pole and 6-pole can be intermixed in any order, in any selector.) Transducers used with the selector modules include thermocouples, PRTs and strain gage bridge configurations. Certain types of transducer, e.g. strain gages, require current energization. This is provided internally by the SI 3535, the energizing currents being automatically switched by the selectors and output to the transducers.

Digital signals consist of status and event inputs, BCD and binary information. Status inputs are represented as logic levels, and can be scanned at speeds up to 500 channels per second. They are handled either as individual channels or in groups regarded as one input.

1.2 RANGE OF MODULE OPTIONS

The range of SI 3535 modules and the main features are summarised below.

Analog Selectors

Reed-Relay Selector SI 35301A.
Solid State Selector SI 35301B.
HVSS Selector SI 35351C.

Each module has 20 input channels for any of the following types of input sensor:

- Voltage (ac or dc),
- Current (ac or dc),
- Resistance*,
- Strain gages,
- PRT,
- Thermocouples.

* Note that only the reed relay selector can be used for two-terminal resistance measurement.

Analog Outputs

Analog Output Module SI 35301E:	This module has five output channels, each of which may be set to provide a current (4mA to 20mA), or a voltage (0V to 10V).

Digital Selectors

Event-Status Input Module SI 35302A:	This module has 20 input channels for status/event digital inputs.
Digital Input/Output Module SI 35302B:	This module has 20 input channels for status digital inputs, and 20 outputs channels for alarm, stimulus or external module measurement.
Counter Timer Module SI 35302C:	This module has five input channels for: ▸ Frequency measurement, ▸ Period measurement, ▸ Totalizing, ▸ Interval measurement.
Transducer Energization Module SI 35351D:	This module generates two energizing currents, or voltages, for use with specific transducers.

EMC COMPLIANCE: CABLE SCREENING

To maintain EMC compliance, the signal cables connected to Scorpio must be screened and the screen connected to a suitable ground.

The screens of cables connected to the following modules should be grounded at the Scorpio termination: Controller, SI 35304B, SI 35301E, SI 35302B, SI 35302C and SI 35351F.

The screens of cables connected to the following input connectors should be grounded at the user (external equipment) termination: SI 35303A, SI 35303B, and SI 35353C.

2 INPUT SELECTORS AND CONNECTOR BLOCKS

2.1 INPUT SELECTION

The function of the Reed-Relay Selector (SI 35301A), the HVSS Selector (SI 35351C) and the Solid State Selector (SI 35301B) is to allow selection and input of up to 20 analog signals to the SI 3535. A selector module of any type can be located in any one of backplane slots 4 to 13 inclusive, allowing up to 10 selectors in total.

The Reed-Relay Selector can handle high input and common mode voltages. The Solid State Selector provides faster switching (up to 500 channels per second) and solid state reliability. The HVSS offers medium speed switching with high input and common mode voltages. The main features of each type of selector are summarized in Table 9.1.

Table 9.1 Main Features of Analog Selectors

Selector Type	Max. I/p Volts	Max. Common Mode Volts	Number of Channels and Poles	Max. Scanning Rate
SI 35301A Reed Relay Selector	105V	200V (any line to earth)	10×6 pole or 20×3 pole or any mixture of 3- and 6-pole channels	150 chans/sec
SI 35301B Solid State Selector	13.7V	14V (any line to earth)	10×6 pole or 20×3 pole or any mixture of 3- and 6-pole channels	500 chans/sec
SI 35351A HVSS Selector	105V	150V (any line to earth)	10×6 pole or 20×3 pole or any mixture of 3- and 6-pole channels	250 chans/sec

Note: If the SI 3535 is fitted with a combination of Reed-Relay, HVSS and/or Solid State Selectors, the input of common mode voltage used must be restricted to that of the lowest specification (Appendix A).

2.2 INPUTS AND SENSORS

The following types of input and sensor can be measured directly:

Input/Sensor	Comments
Voltage dc, 1µV to 100V Voltage ac, 10µV to 19V	See Table 9.1 for maximum input voltages applicable to the various input selectors.
Resistance, 1mΩ to 130kΩ	This includes PRTs and thermistors. Resistance measurement employs a 100µA energizing current.
Strain gage	120Ω or appropriate resistance. Full-bridge, half-bridge or quarter-bridge gages can be accomodated. For a full-bridge, 120Ω gages may be energized from a 2V supply only, whilst 350Ω gages may be energized from either a 2V supply or a 10V supply. (**NOTE:** 10V energization may not be used with the SI 35301B Solid State Selector.) Quarter-bridge strain gages employ a common dummy gage, fitted locally or remotely.
Thermocouples	Includes thermocouple types E, K, J, B, N, T, R and S.
Current ac/dc, 0.1µA to 25mA	Current measurement employs a SI 35303B Input Connector or SI 35303A Input Connector, with additional 100Ω shunt resistors.

COMMON MODE VOLTAGES AND SWITCHING SPIKES

To avoid switching spikes being generated at the inputs of analog selectors take the following precautions regarding common mode dc voltages:

- Try to ensure that all guard inputs on the same analog selector are at the same common mode potential.
- Where guard inputs unavoidably have different common mode potentials on the same analog selector, limit the amplitude of possible input spikes by:
  (a) ensuring that the common mode potential difference between successively selected channels is as small as possible, or
  (b) placing a "dummy" channel, with guard at ground potential, between channels whose guard potentials are markedly different.

2.3 SENSE AMPLIFIERS

When the SI 3535 is fitted with the SI 35351D Transducer Energization Module, two different Sense amplifiers are automatically configured internally, according to the type of sensor defined for each input. A simplified diagram showing the Sense amplifiers as configured for strain measurements using a quarter bridge with remote dummy is shown in Fig 9.1.

The main sense amplifier monitors the S (sense) connection at the strain gage and controls the output (IC) such that a potential of 0V is maintained at the gage. The auxiliary sense amplifier maintains the S2 connection to the dummy at 0V, in a similar manner. The sense amplifiers thereby maintain both points at 0V without the need to connect the points together or to use floating current supplier. This effectively compensates for any voltage drop which may be present in the current return lines IC and IC2.

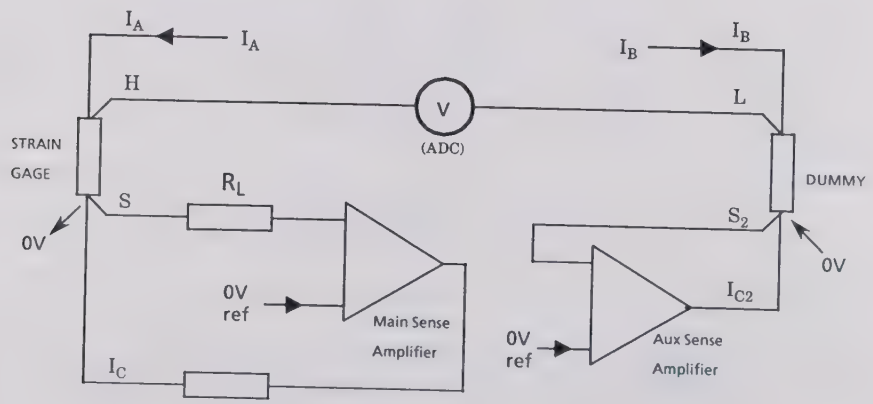


Fig 9.1 *Sense amplifier.*

2.4 INPUT CONNECTORS

Three types of input connector are available, which allow sensors and transducers to be connected to the SI 3535 by means of screw terminals (Fig 9.2). The input connectors are:

SI 35303A — This type of connector includes two thermistors, and can be used for all types of input. Applications involving thermocouple measurements use the connector as the cold junction for sensing ambient temperature.

SI 35303B — This type of connector is primarily intended for current measurements; a 100 ohm shunt resistor is fitted internally across each input channel. It can also be used for other types of input with high impedance.

SI 35353C — (Isothermal junction block) This type of connector is for improvement of cold compensation. The connector uses PRT connector sensors for measurement and can be used with the SI 35301A (reed relay) or SI 35351C (*high-voltage* solid-state) selectors, but not with SI 35301B (solid-state) selectors.

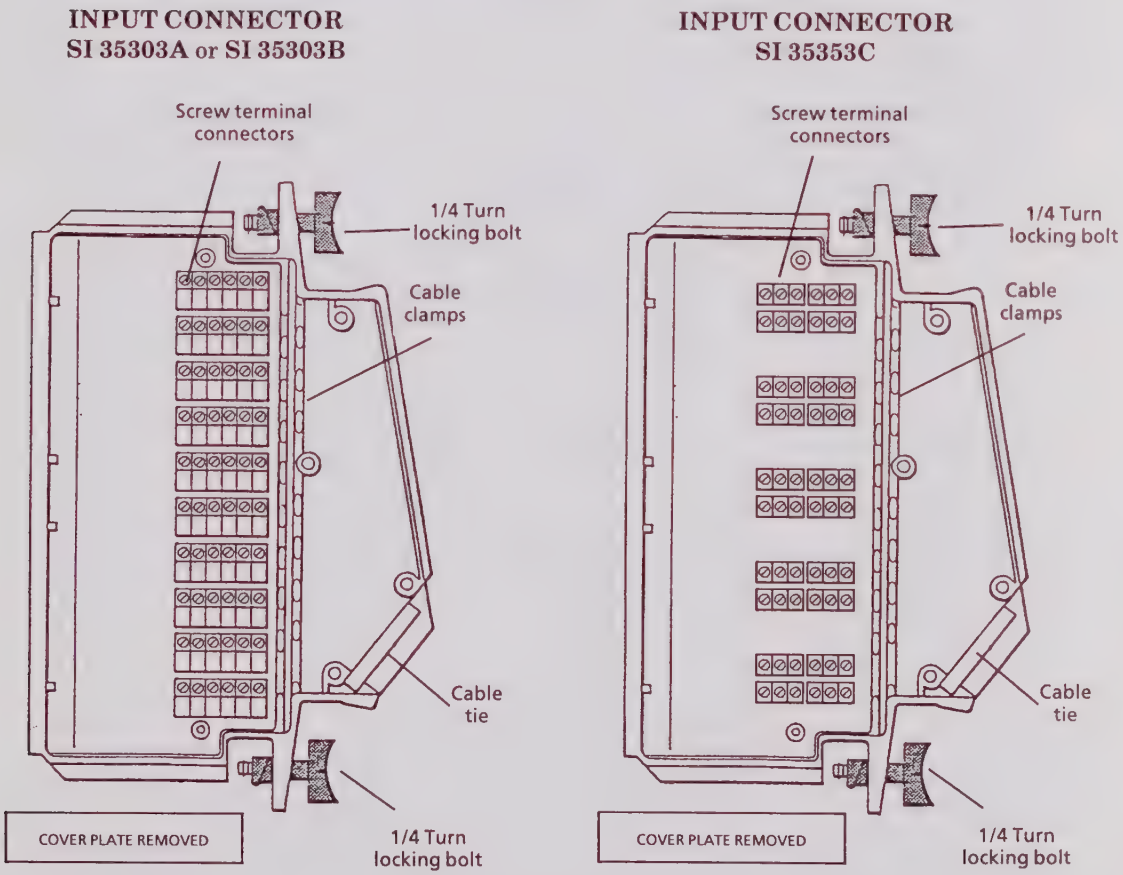


Fig 9.2 *Input Connectors*

2.5 CHANNEL NUMBERS

For each module option within the SI 3535, the channels are numbered in groups of 20. The range of specific numbers, e.g. 1-20, 21-40 etc, is dependent on the location of the module in the mainframe, as shown in Fig 9.3.

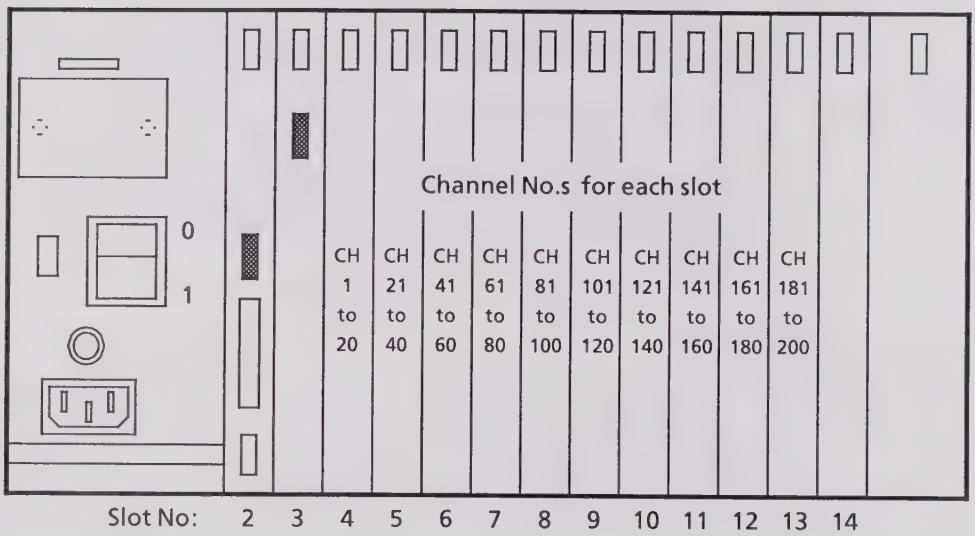
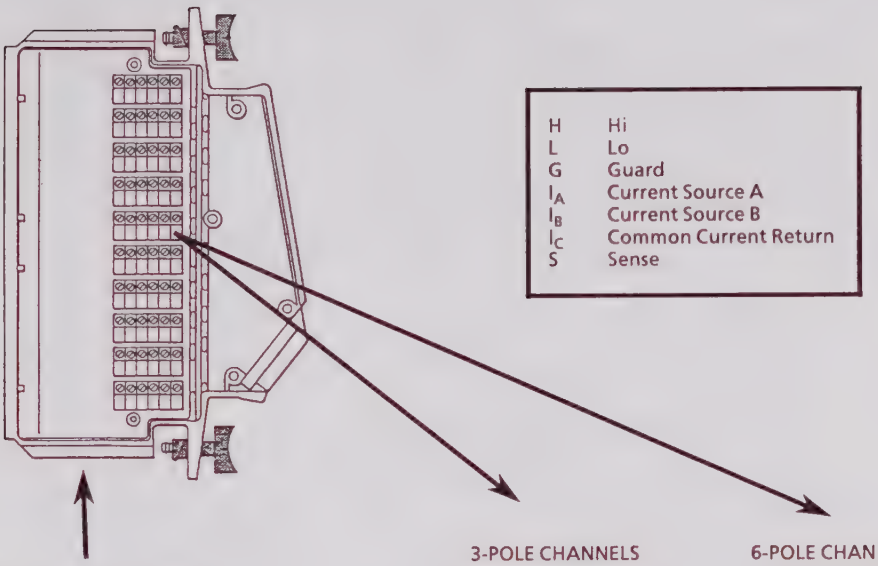


Fig 9.3 *Channel numbering.*



H	Hi
L	Lo
G	Guard
I_A	Current Source A
I_B	Current Source B
I_C	Common Current Return
S	Sense

INPUT CONNECTOR ASSEMBLY
(COVER PLATE REMOVED)
SI 35303A

Channel numbering and pin assignments for 3-pole and 6-pole channels are shown. In practice, any mix of 3-pole and 6-pole channels on the same connector is permitted. Note that 6-pole channels always have odd numbers.

The numbering is shown for channels 1 to 20 only; subsequent sets of channels (10 to 20) are similarly numbered, i.e. 21 to 40, 41 to 60, and so on, up to 181 to 200. Channel numbering on any input connector is dependent on which slot it occupies in the SI 3535 mainframe.

This applies also to the connector block type SI 35353C.

3-POLE CHANNELS						6-POLE CHANNELS					
1			2			1					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
3			4			3					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
5			6			5					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
7			8			7					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
9			10			9					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
11			12			11					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
13			14			13					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
15			16			15					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
17			18			17					
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
H	L	G	G	L	H	I_A	I_B	I_C	S	L	H
19			20			19					

Fig 9.4 *Channel allocation – input connectors.*

Pin assignments are automatically set by the software for 3-pole or 6-pole channels.

i.e. H, L, G for 3-pole
I_A, I_B, I_C, S, L, H for 6-pole

Note that 6-pole channels always have odd numbers, the next corresponding even number is omitted.

CHANNELS 41-60
(Slot 6 in logger mainframe)

41			42		
H	L	G	G	L	H

43			44		
H	L	G	G	L	H

45					
I_A	I_B	I_C	S	L	H

47			48		
H	L	G	G	L	H

49					
I_A	I_B	I_C	S	L	H

51					
I_A	I_B	I_C	S	L	H

53					
I_A	I_B	I_C	S	L	H

55			56		
H	L	G	G	L	H

57			58		
H	L	G	G	L	H

I_A	I_B	I_C	S	L	H
59					

Fig 9.5 *Channel allocation, 3-pole and 6-pole channels combined.*

2.6 GUARD CONNECTION USING SPLIT PADS

Guard (or Sense) must always be connected. For all 3-terminal inputs, Guard must be connected to either the source of common mode, or directly to the Lo input. For all 6-terminal inputs, Sense must be connected.

On the Reed Relay and HVSS Selectors, Guard can be linked to Lo by bridging either of two solder pads. These pads are identified as SP1 or SP2 on the Reed Relay Selector and SP3 and SP2 on the HVSS Selector. (See Fig 9.6.)

This internal linking of Guard to Lo may be used when all odd or all even input channels are to be used for similar voltage or thermocouple inputs. The external G (guard) to L (Lo) connection can then be omitted. SP1 (SP3) links G to L on all odd channels and SP2 (SP2) links G to L on all even channels.

CAUTION: If either L-G link is made, the input connections are simplified, but it should be noted that all the associated channels are committed to the same L to G connection and that the best immunity to common mode voltage may not then be provided.

Note also that the L-G links should *not* be connected when:

(a) an SI 35353C Isothermal Connector is used (L-G connection would corrupt isothermal temperature measurement) or

(b) a mixture of 3-pole and 6-pole channels is used on the same selector.

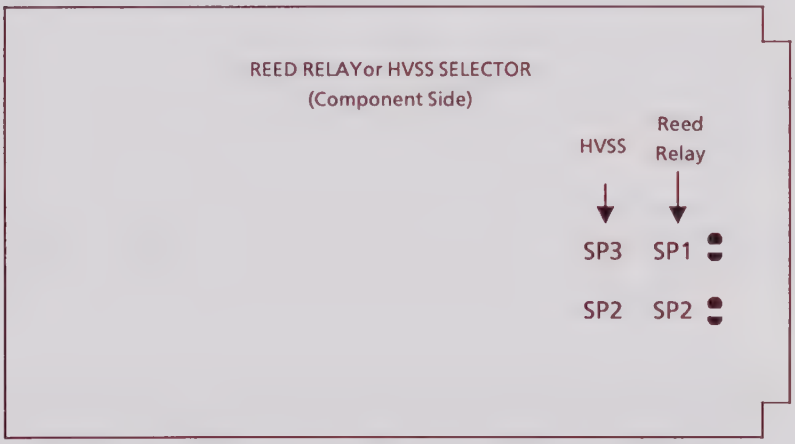


Fig 9.6 *Locations of the L-G links SP1 (SP3) and SP2 on the input selector card.*

2.7 VOLTAGE MEASUREMENT CONNECTIONS

Theoretically, voltage measurement is represented as indicated in Fig 9.7. In practice, the internal connections are as shown in Fig 9.8.

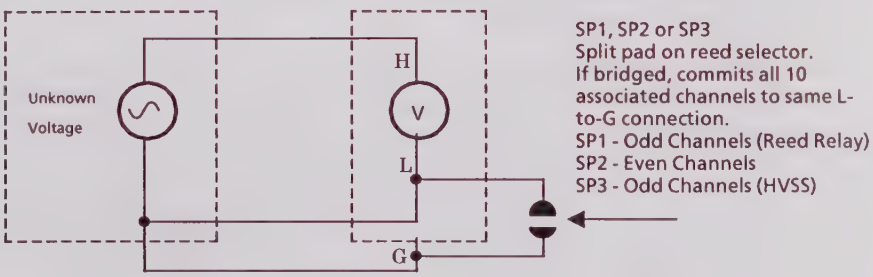


Fig 9.7 *Theoretical voltage measurement schematic.*

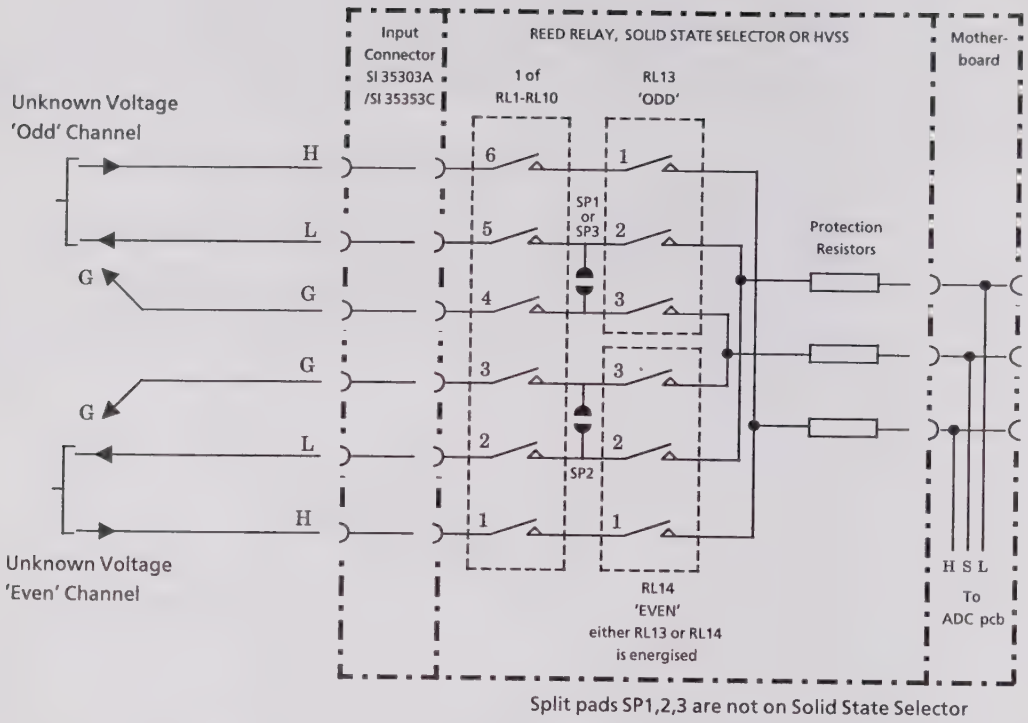


Fig 9.8 *Signal organisation, voltage measurement.*

2.8 CURRENT MEASUREMENT CONNECTIONS

Current measurement is based on passing the current to be measured through a resistance of known value in a 3-pole connection. Practical connection details and signal organization at the analogue selector interface are shown in Fig 9.10 and Fig 9.11 respectively. It is also possible to use the conversion facility (Chap 7) to convert the measured voltage into current.

2.9 RESISTANCE MEASUREMENT CONNECTIONS

In a similar way to that used to determine current, the value of an unknown resistance can be determined by passing a known value of current through the resistance. In practice the required energizing current is generated by the SI 3535.

The values of voltage measured are automatically converted to the appropriate units of resistance within the SI 3535.

For applications in which accuracy is not the outstanding criterion, resistance measurements can be made using a two-terminal, three-pole connector as shown in Fig 9.12 and Fig 9.13. NOTE, HOWEVER, THAT THIS SHOULD BE DONE ONLY WITH A REED RELAY SELECTOR. For greater accuracy, a four-terminal connection should be used (as for PRT measurement —Fig 9.16). Four-terminal resistance measurements can be made with any of the SI 3535 selectors, i.e. reed relay, solid-state or high voltage solid-state.

2.10 THERMOCOUPLE MEASUREMENT CONNECTIONS

Thermocouples can be connected to the SI 3535 using two different methods, each providing a different cold junction arrangement. (The cold junction of dissimilar metals can be at ambient or some other known reference temperature.) The connection methods are as follows:

a) The thermocouple leads are taken directly to the SI 3535 module input terminals, which form the cold junction. The cold junction temperature is sensed by thermistors built into the Input Connector (SI 35303A or SI 35353C).

b) The thermocouple leads are connected to copper connecting leads which form the cold junction, and the copper leads are taken to the input terminals. This arrangement allows the cold junction to be placed at any suitable user location, at which the precise temperature is known (e.g. 0°C melting ice).

Connections for both these arrangements are shown in Figs 9.14 and 9.15.

2.11 PRT MEASUREMENT CONNECTIONS

In addition to using thermocouples for temperature measurement, it is also possible to use Platinum Resistance Thermometers (PRT). Measurements are made using a 4-terminal 6- pole connection as shown in Fig 9.16. The corresponding signal organization is shown in Fig 9.17.

2.12 STRAIN GAGE MEASUREMENT CONNECTIONS

Strain gages can be used in several different bridge configurations. The names of these relate to that part of the bridge located at the measurement site, as follows:

(a) Full-bridge. Conventional four-arm bridge at the measurement site. One or more of the gages may be a "dummy", i.e. an unloaded gage or a resistor that simulates a gage. Full bridges are energized by a constant voltage from the SI 35351D Transducer Energization Module. (See Figs 9.18 and 9.19.)

(b) Half-bridge. Two gages, i.e. half a bridge, at the measurement site. One of these gages may be a dummy. Half bridges are energized by two constant currents from the SI 35351D Transducer Energization Module. These currents replace those that would flow through the two "top" arms in a full bridge. (See Figs 9.20 and 9.21.)

(c) Quarter-bridge. One gage only at the measurement site. This is a variation of the half-bridge configuration, in which a "common dummy" is shared by several quarter bridges: the common dummy is switched to each quarter bridge in turn as strain measurements are taken. The common dummy may be placed either at the measurement site (local dummy) or at the logger (remote dummy). (See Figs 9.22 and 9.23.)

(d) Three-wire quarter bridge. This version of the quarter bridge uses three wires to connect each measurement gage to the logger, which is one wire less than configuration (c). However, a dummy gage must be used for each strain channel. (See Figs 9.24 and 9.25.)

The dummy gages necessary for quarter-bridge strain measurement are contained on the SI 35351D Transducer Energization Module (Section 3). One 120Ω remote dummy (Rem 120) is fitted as standard, and there is provision for the user to fit three additional local or remote dummies (Fig 9.26) as follows:

User X	Remote dummy only.
User Y	Local or remote.
User Z	Local or remote.

Any one dummy can be used with any number of (quarter-bridge) gages, providing that the dummy resistance and the nominal gage resistance are similar, and that the gages all require a local or a remote dummy. A dummy is automatically switched to a selected gage by means of the internal switches.

Prior to measuring strain, the gages should be initialised using the "Init Chan" facility of the PROGRAM MENU. The procedure is:

1. Set up the strain gages with zero load.

2. Press the PROGRAM MENU key, the Etc. soft key and the Init Chan soft key.

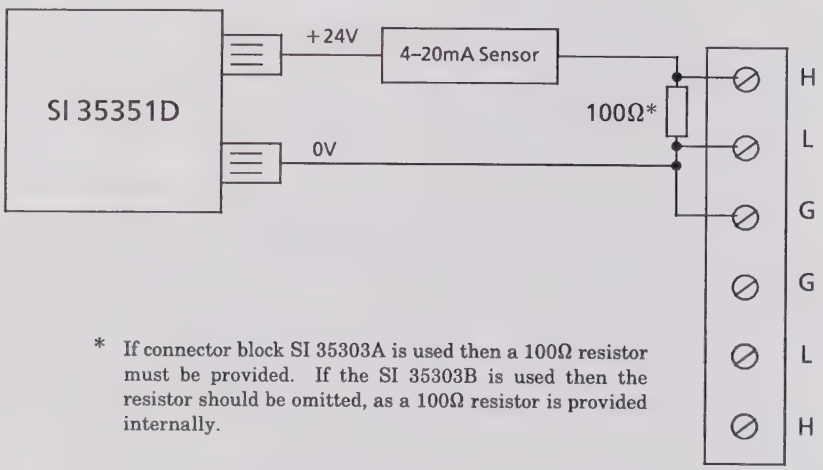
3. Enter the channels to be initialised, i.e. those channels to which the strain gages are connected.

The SI 3535 now measures the zero load value from each of the specified channels and, for subsequent strain measurements, subtracts the zero load value from the loaded value to give the correct strain value.

2.13 4–20mA SENSOR CONNECTIONS AND PROGRAMMING

4–20mA sensors may be accommodated using the 24V output from the SI 35351D TEM to provide the energization. The number of 4–20mA sensors must be limited such that the maximum current drawn from from the SI 35351D (TEM) is 1A.

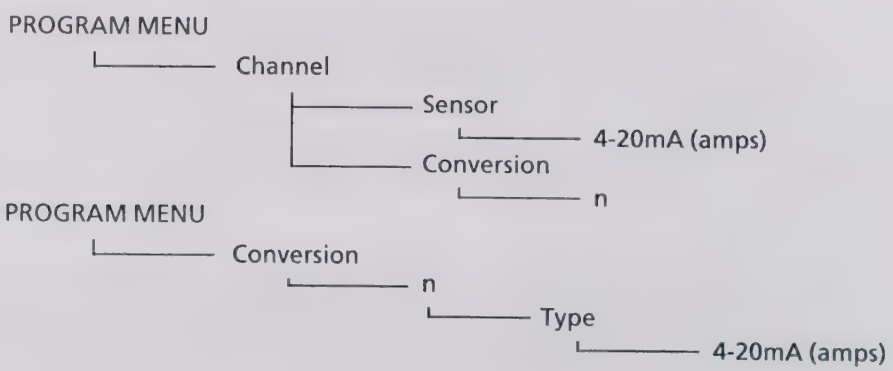
In order to use the 4–20mA sensors the wiring shown in Fig 9.9 must be used:



* If connector block SI 35303A is used then a 100Ω resistor must be provided. If the SI 35303B is used then the resistor should be omitted, as a 100Ω resistor is provided internally.

Fig 9.9 *Wiring for 4–20mA sensors.*

A 4–20mA sensor channel may be set up under the program menu, by defining the channel to be 4–20mA (or amps) and assigning a conversion which is then set to the 4–20mA type:



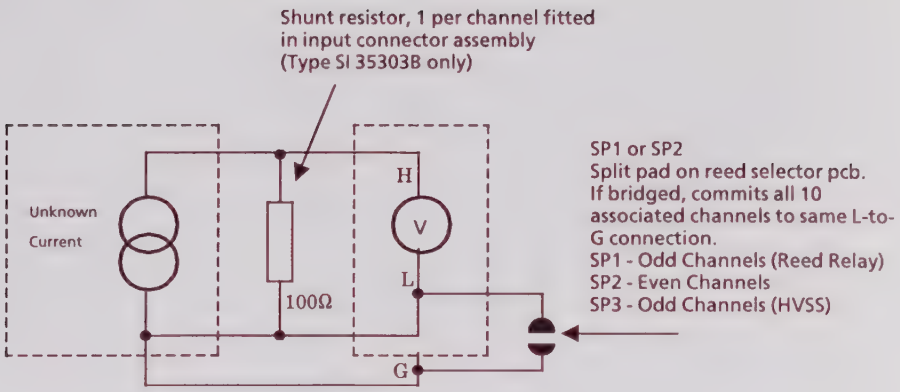


Fig 9.10 *Theoretical schematic of current measurement.*

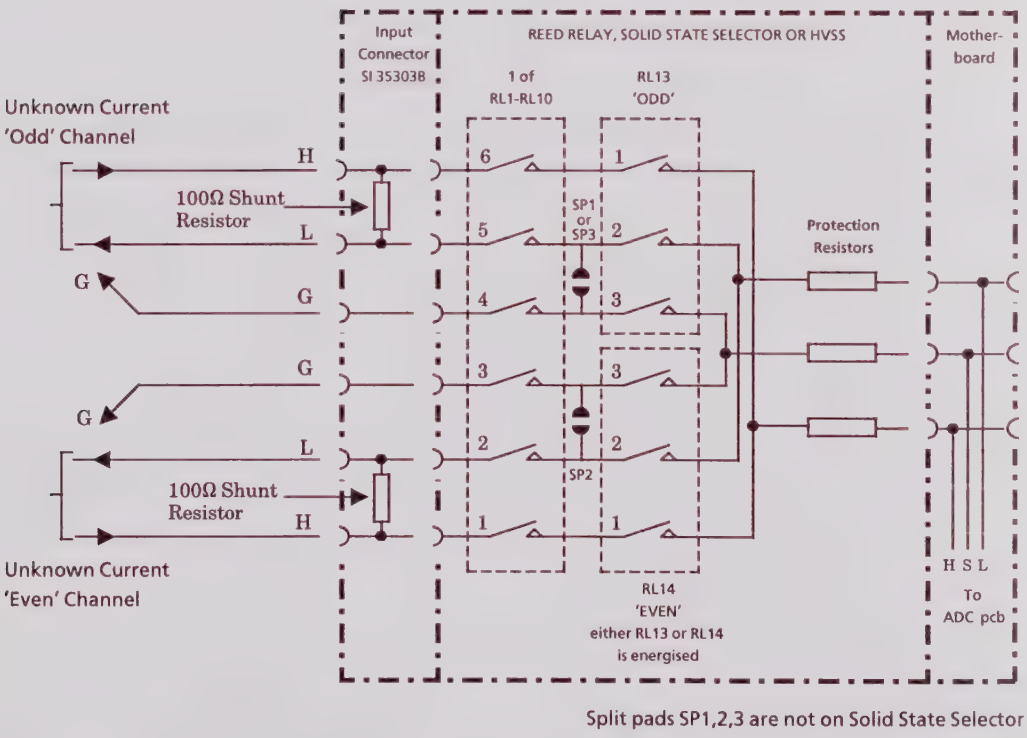


Fig 9.11 *Signal organisation, current measurement.*

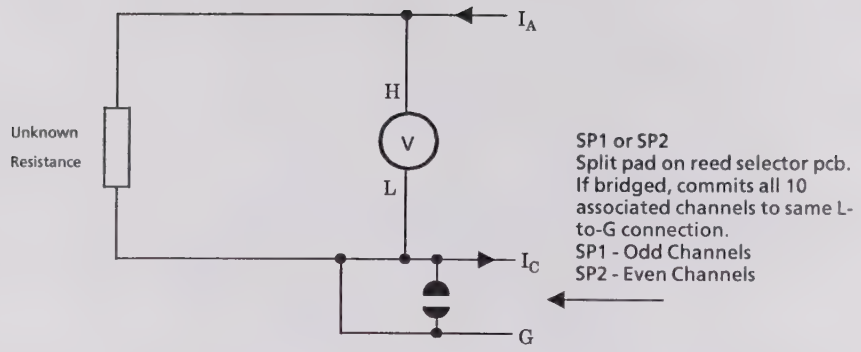


Fig 9.12 *Theoretical schematic of two-terminal resistance measurement. N.B. This configuration is possible only with an SI 35301A Reed Relay Scanner. For greater accuracy use four-terminal resistance measurement. (See Section 2.9 in this chapter.)*

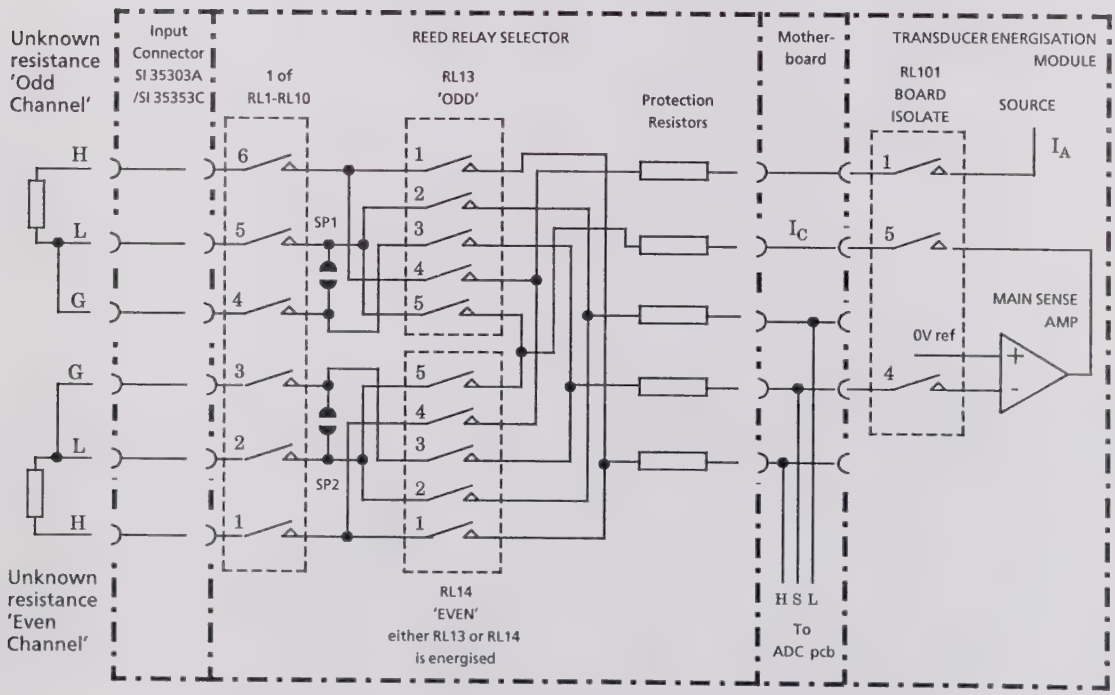


Fig 9.13 *Signal organisation, two-terminal resistance measurement.*

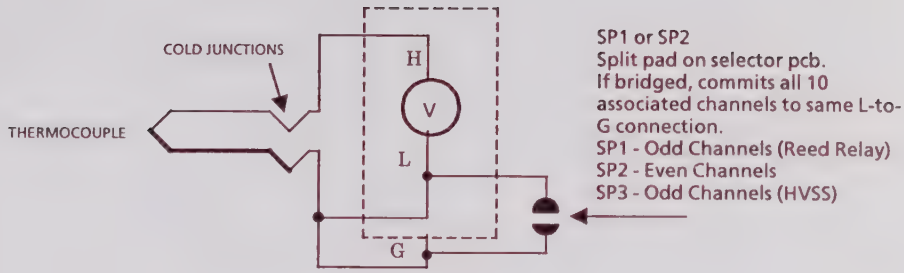


Fig 9.14 *Theoretical schematic of thermocouple.*

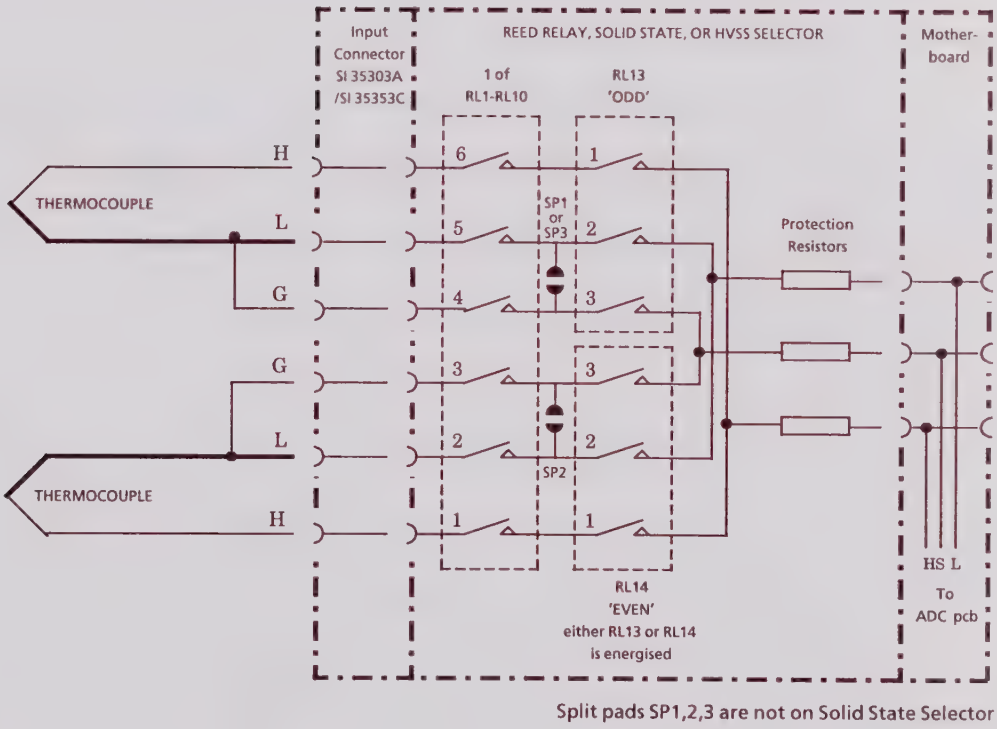
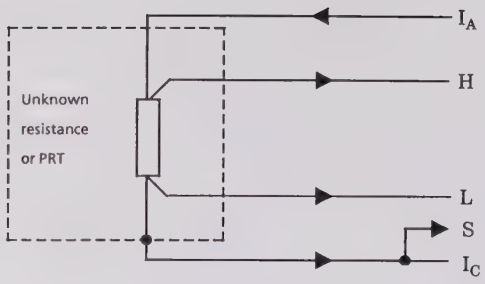


Fig 9.15 *Signal organisation, thermocouple.*



The energising current is generated and switched automatically, no additional linking or connections are required.

Fig 9.16 *Theoretical schematic of PRT.*

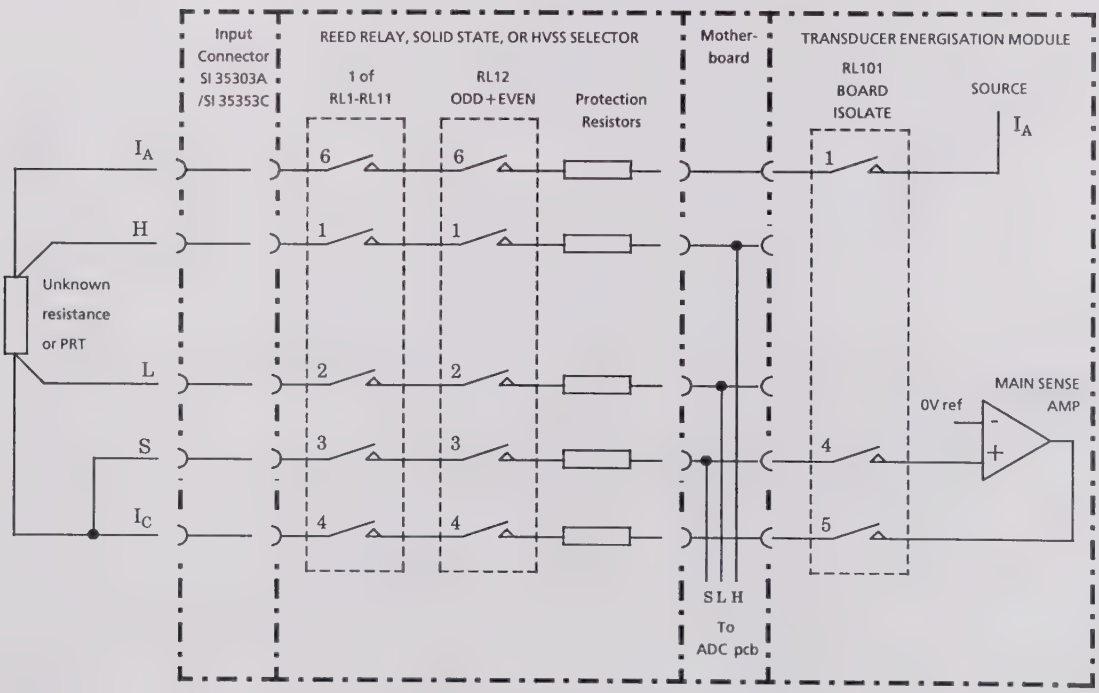
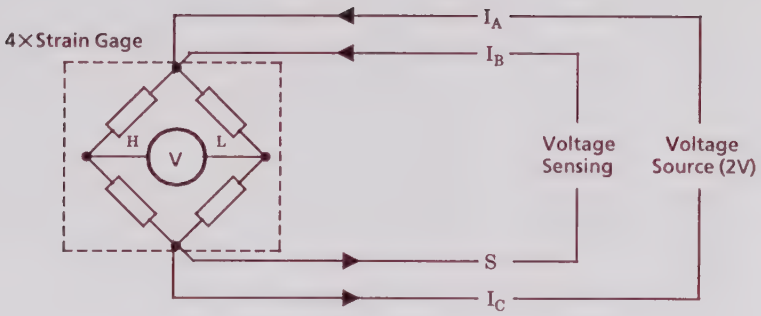


Fig 9.17 *Signal organisation, PRT.*



The energising voltage is generated and switched automatically, no additional linking or connections are required. Although the terminals used are the same as for current energisation, this configuration uses voltage energisation 2V or 10V (Not with Solid State Selectors fitted).

Fig 9.18 *Theoretical schematic of full-bridge strain gage.*

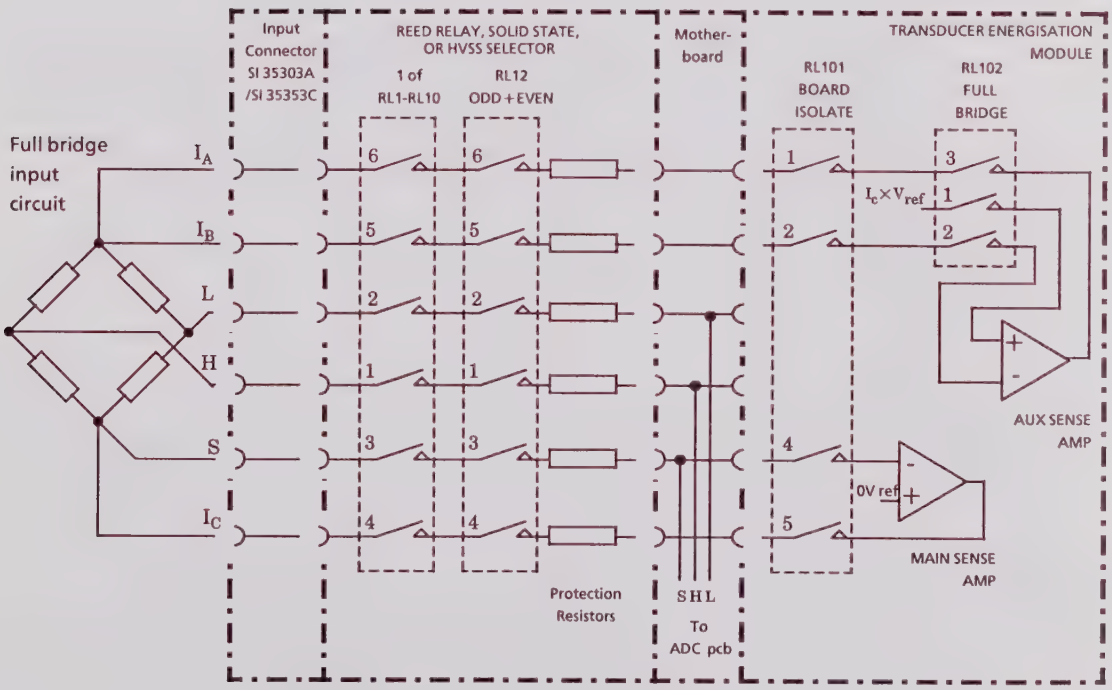
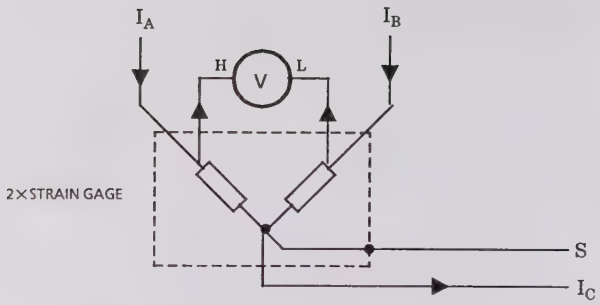


Fig 9.19 *Signal organisation, full-bridge strain gage.*



The energising currents are generated and switched automatically: no additional linking or connections are required.

Fig 9.20 *Theoretical schematic of half-bridge strain gage.*

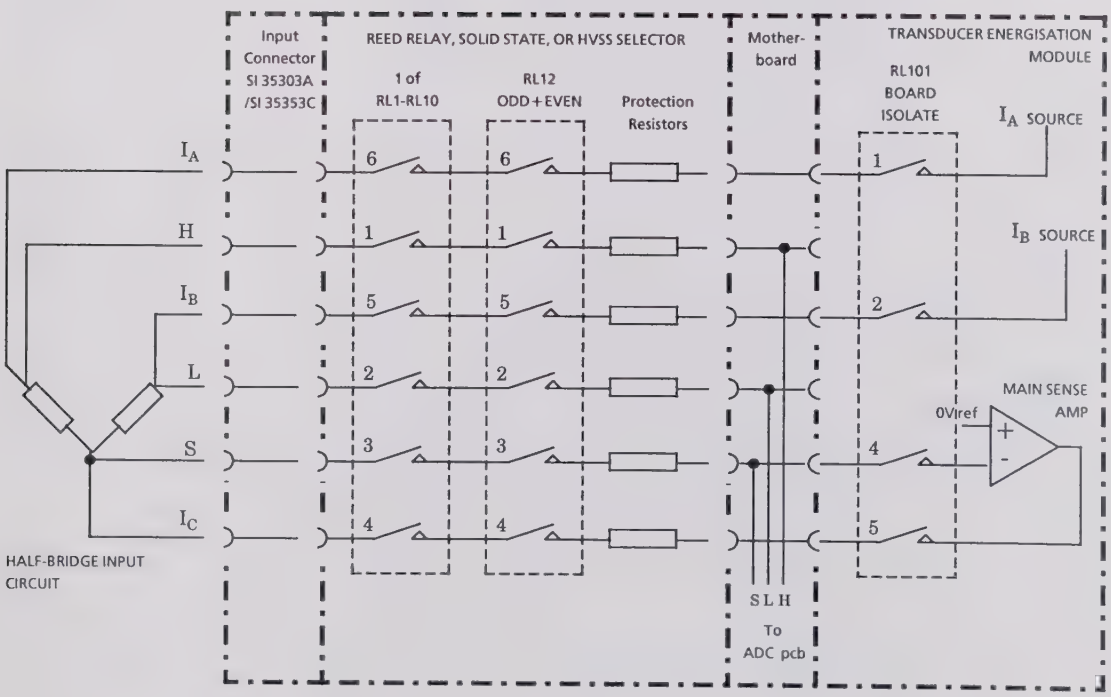
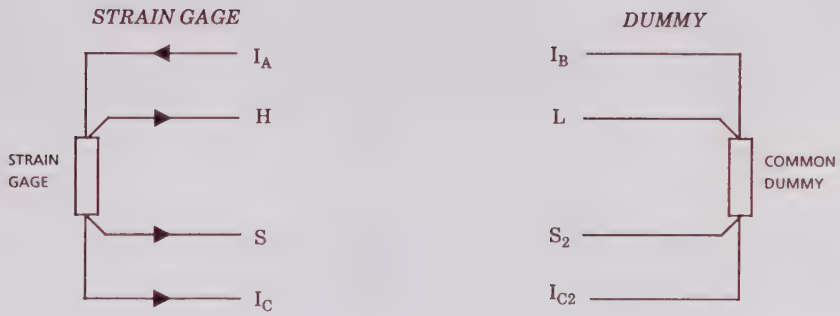


Fig 9.21 *Signal organisation, half-bridge strain gage.*



The energising currents are generated and switched automatically, no additional linking or connections are required.

Fig 9.22 *Theoretical schematic of quarter-bridge strain gage.*

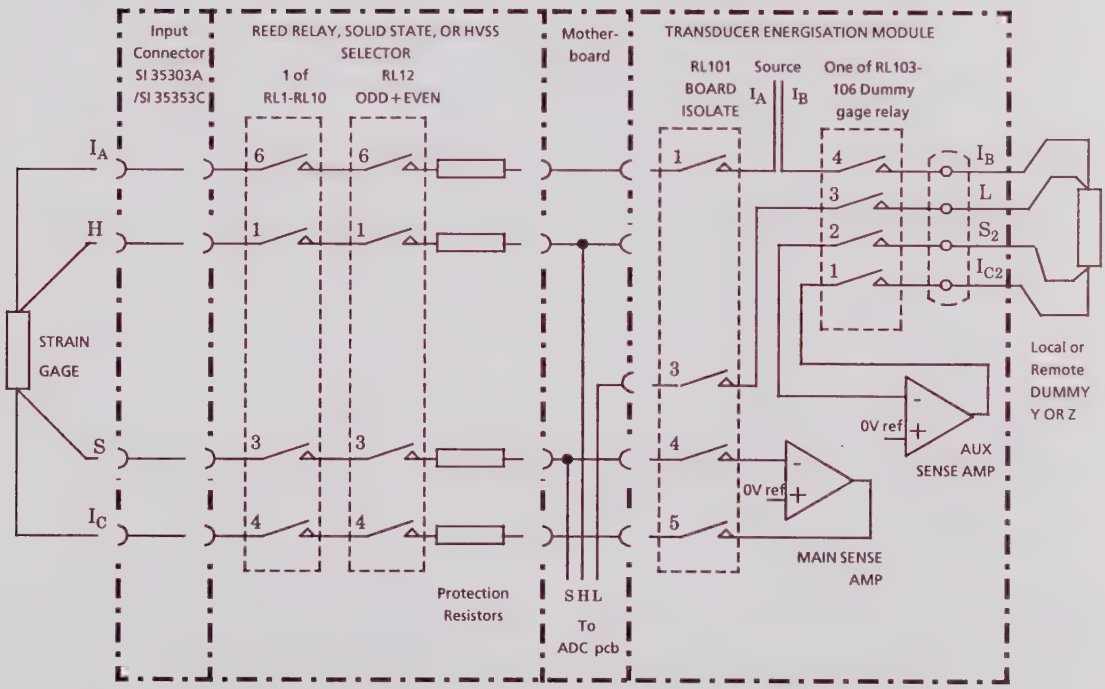
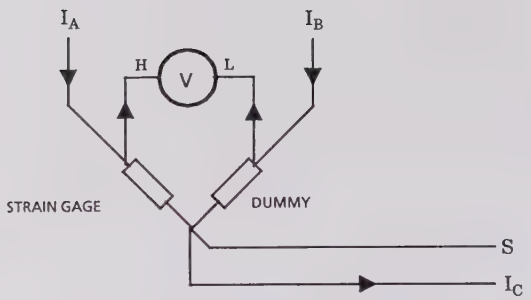


Fig 9.23 *Signal organisation, quarter-bridge strain gage.*



The energising currents are generated and switched automatically, no additional linking or connections are required.

Fig 9.24 *Theoretical schematic of three-wire strain gage.*

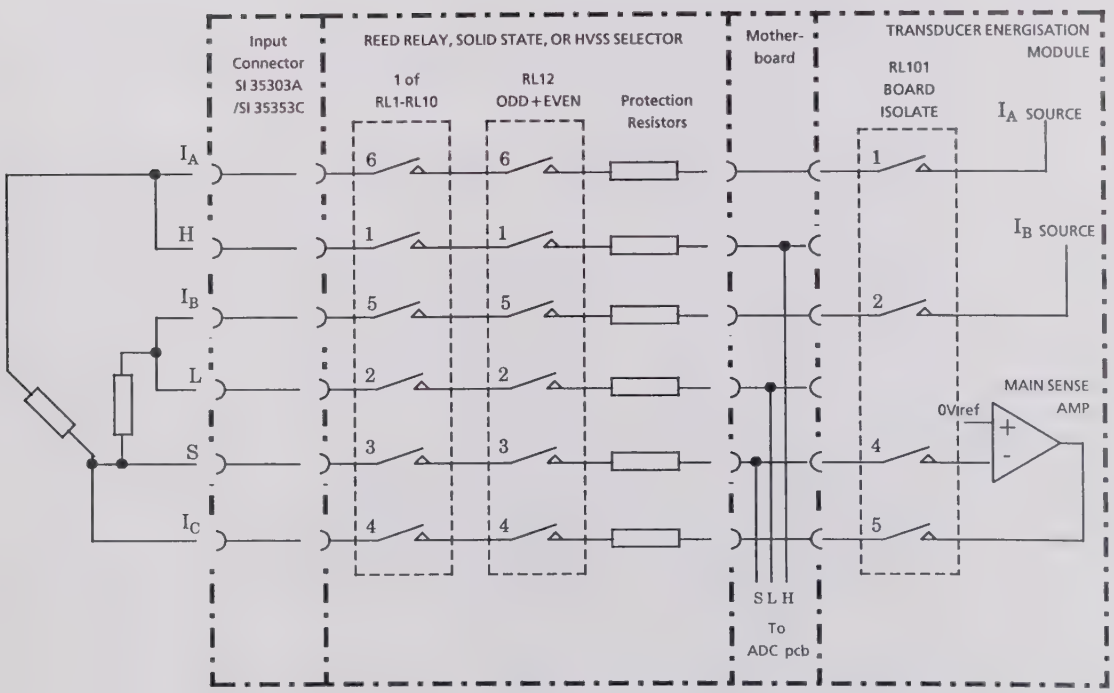


Fig 9.25 *Signal organisation, three-wire strain gage.*

3 TRANSDUCER ENERGIZATION MODULE

The SI 35351D Transducer Energization Module (TEM) is used in conjunction with the Reed Relay, HVSS and Solid State Selectors (Section 2) to provide constant current energization for certain types of transducer. Constant voltage energization, for full-bridge strain gages, is available also. The SI 35351D must be fitted in slot 14 of the SI 3535 backplane.

3.1 CURRENT DEFINITION

For constant current energization the SI 35351D module produces two energizing currents, I_A and I_B, which can be programmed as: 8.33 mA, 1 mA, 100µA, or a user-defined value. For full-bridge energization the two currents are controlled automatically by an auxiliary amplifier in the SI 35351D to maintain the required energization voltage.

The user-defined values for I_A and I_B are set independently by fitting two additional resistors to the pcb. The value of each resistor is determined by $R = 6/I$, where,R = resistance (ohms) and I = current (amps).

The resistor for I_A is connected between P200 and P201 and the resistor for I_B is connected across P202 and P203. Normally, I_A and I_B are set to the same value, but they can be different if required. User-defined currents can be set to any value betweem 10mA and 100µA.

NOTE: The current drawn from the 24V supply via the transducer energization module and the counter-timers must not exceed 1A in total.

3.2 CURRENT-DEFINING RESISTORS

To fit these resistors for a specific transducer requirement, proceed as follows:

1. Switch off the SI 3535 and remove the transducer energization module from slot 14 in the backplane.
2. To define I_A and I_B, fit a suitable resistor across P200 and P201 for I_A, and another across P202 and P203 for I_B.
3. Replace the transducer energization module in slot 14.

3.3 FITTING DUMMY GAGES

To fit a dummy gage to the transducer energization module, proceed as follows:

1. Switch off the SI 3535 and remove the transducer energization module from slot 14 in the backplane.
2. See Fig 9.26 for location of terminals to which dummies X, Y and Z should be connected.
3. To fit User X dummy, remove the module cover plate, and solder the dummy between the two solder pads.
4. To fit User Y or User Z dummies, connect to SK1 or SK2 (Fig 9.27).

   Note:Either or both of these dummies can be used as local or remote (Section 2.13). In Fig 9.27, dummy Y is shown as local and dummy Z is shown as remote. For local dummies, pass the leads connecting the dummy to SK1 or SK2 through the hole provided in the extrusion. Locate the local dummy close to the associated gage(s).

5. Replace transducer energization module in slot 14.

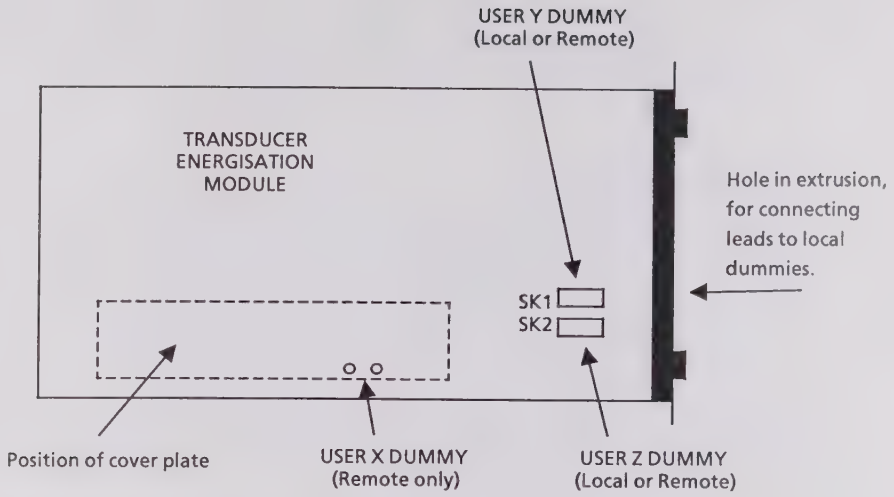


Fig 9.26 *Location of Dummies on Transducer Energization Module.*

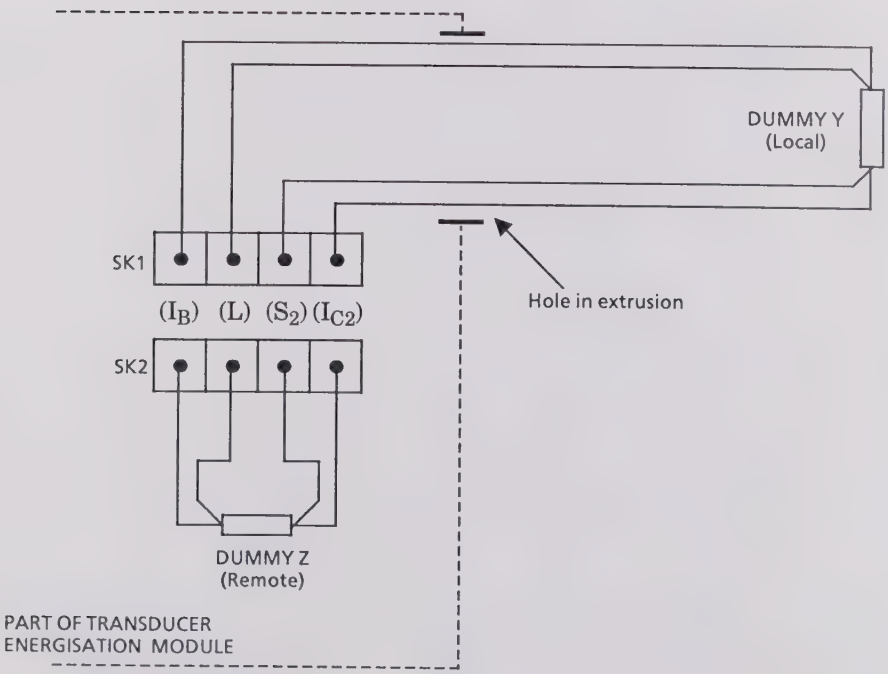


Fig 9.27 *Connections to Dummies Y and Z.*

4 EVENT-STATUS INPUT MODULE

The function of the Event-Status Input Module (SI 35302A) is to enable detection and acquisition of up to 20 digital signals. The logic convention adopted is that a logic '0' is represented by the presence, and logic '1' the absence of a current or voltage at the signal input. The actual voltage levels recognised by the system are defined in the module specification in Appendix A of this manual. Typical input circuit schematics are shown in Fig 9.28.

4.1 EVENT INPUTS

Event inputs are continuously monitored during an active task, and logic level transitions are recorded. Front panel menu displays refer to transitions in the following way:

Lo-to-Hi: represents a '0' to '1' transition.

Hi-to-Lo: represents a '1' to '0' transition.

Any: represents either transition.

Selection of "Any" identifies either a "Lo-to-Hi" or a "Hi-to-Lo" transition as an event. An example of use could be to detect the opening and closing of a switch, both of which are classified as events. Inputs are monitored continuously during the relevant Task, and events are detected as soon as they occur. All events detected are regarded as alarms.

Note that any event input pulse actually consists of two transitions:

Lo-to-Hi and Hi-to-Lo, or Hi-to-Lo and Lo-to-Hi

Both transitions, in either case, contribute to the total detected by the processor, even though only the Lo-to-Hi, or the Hi-to-Lo, transition is selected for processing/alarm action.

The time at which an event occurs is measured to an accuracy of 2ms. (The minimum pulse length for an event input is 2ms, i.e. it must remain in the Hi, or Lo, state for not less than 2ms to be detected. The total event processing time is 2ms.)

4.2 STATUS INPUTS

For status inputs the actual logic states are recorded. During a defined Scan the SI 3535 monitors the input voltage level (i.e. 0V or 5V) for each status input, at 500 channels per second. Status inputs can be used as individual channels, or grouped together. For each separate status input channel, the logic state (1 or 0) is dependent on whether the input circuit is conducting or not. If conducting, a logic '0' is detected: if not, a logic '1' is detected. The channel alarm state can be defined as '0' or '1'.

In addition to defining the alarm state of an individual channel, it is possible to group together a number of consecutive channels (maximum of 8) and define the group state as an alarm, e.g. a typical group state would be 1101 for a 4-channel group.

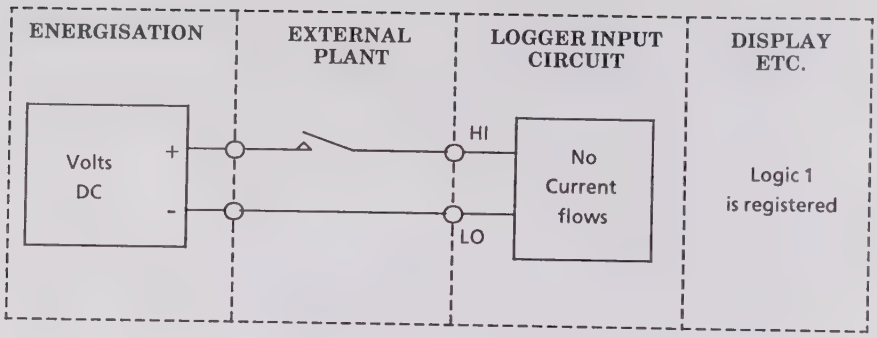


Fig 9.28a *Event-status input circuit: logic 1.*

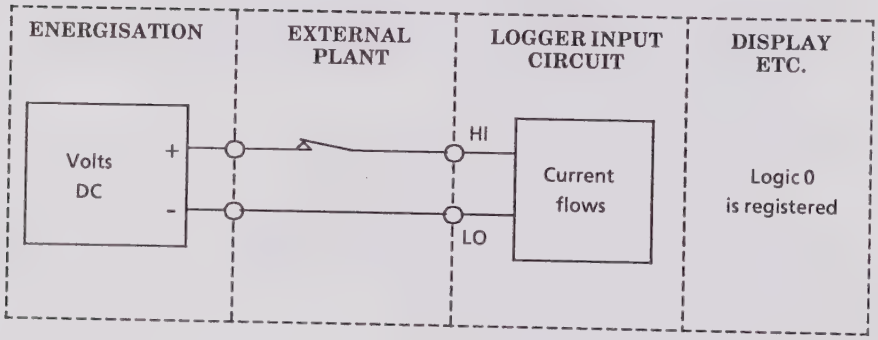


Fig 9.28b *Event-status input circuit: logic 0.*

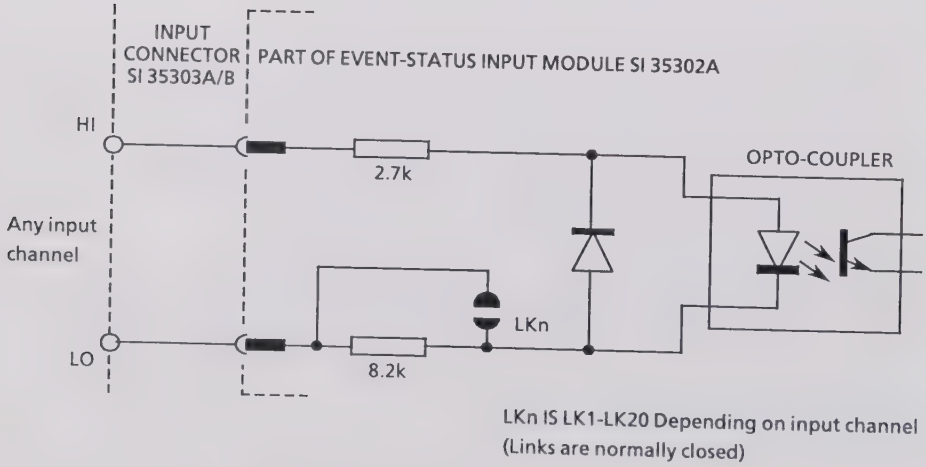


Fig 9.28c *Event-status input circuit: channel circuit.*

4.2.1 BCD Channels

Status inputs can be used to read binary coded decimal (BCD) decades in the form 8-4-2-1. Input of BCD can be in either normal or inverted form, as selected as part of the Channel Definition. An example of both forms is given below for the number 9:

	8	4	2	1
Normal BCD	0	1	1	0
Inverted BCD	1	0	0	1

Four consecutive input channels are used by each BCD decade, the least significant bit (lsb) being the lowest channel number, and the most significant bit (msb) being the highest channel number, e.g. for channels 1 to 4, bit significance is as follows:

Channels:	4	3	2	1
BCD Significant:	8	4	2	1

Successive decades are connected in a similar way, with up to 5 decades per module:

Channel number:	12	11	10	9	8	7	6	5	4	3	2	1
BCD significance:	800	400	200	100	80	40	20	10	8	4	2	1
	100s decade				10s decade				1s decade			

NOTE: When a group of 4 channels is used as a BCD decade (e.g. 1 to 4) the whole group is referred to by the lowest channel number in the group (e.g. 1). Similarly, if channels 1 to 20 are used for 5 BCD decades, only channel 1 is declared in the Channel Definition, and the SI 3535 automatically assigns the rest of the channels in sequence.

For each BCD decade, the logic levels for the 4 separate input channels are detected and converted into a decimal number.

4.3 STATUS INPUT ALARMS

4.3.1 Single Channels

The simplest case is of one status input channel which produces inputs for a measured result of logic '1' or logic '0'.

Alarm on Match: Select 1 or 0, which represents an alarm level of logic '1' or logic '0' respectively.

When the levels match the detected logic level is the same as the selected level and an alarm occurs. If the levels are different an alarm does not occur.

Alarm on Mismatch: Select 1 or 0, which represents an alarm level of logic 1 or 0 respectively.

When the levels mismatch the detected logic level is different from the selected level and an alarm occurs. If the levels are the same an alarm does not occur.

Match and mismatch levels are referred to as patterns.

4.3.2 Grouped Channels

Status inputs can be used as a group of up to 8 channels. In the simplest situation it is normal for any group to consist of consecutive channels, e.g. channels 21 to 28 could be used as an 8-channel group. The whole group is referred to by the lowest channel number only, e.g. 21.

During scanning of a group of channels the output from each channel is detected and the result for the whole group is output as a pattern of logic '1's and '0's. For example, the 8-channel group referred to as Channel 21 could produce the following result:

Ch 21 00110010

Correspondence with separate channels in the group is as follows:

Channel number:	28	27	26	25	24	23	22	21
Logic level detected:	0	0	1	1	0	0	1	0

The lowest numbered channel appears on the right, and the highest on the left.

To set up an alarm condition for grouped channels, select pattern Match or Mismatch, and a pattern of logic '1's and '0's (or * for "don't care" channels).

Alarm on Match:

Select a logic '1' or '0' for each channel in the group. For example, for an 8-channel group, set up a total of 8 logic '1's or '0's, which, typically, could be 00010001, representing an alarm pattern. When the patterns match, i.e. the measured pattern is the same as the alarm pattern selected, an alarm occurs. If the patterns are different, then no alarm occurs. An example follows:

Measured pattern:	01010000
Alarm pattern selected:	00010001
Result:	NO ALARM
Measured pattern:	01010001
Alarm pattern selected:	00010001
Result:	ALARM

Alarm on Mismatch:

Select a logic '1' or '0' for each channel in the group, to represent an alarm pattern. When the patterns mismatch, i.e. the measured pattern is different from the alarm pattern selected, an alarm occurs. If the patterns are identical, then no alarm occurs. An example follows:

Measured pattern:	01010000
Alarm pattern selected:	01010000
Result:	NO ALARM
Measured pattern:	01000000
Alarm pattern selected:	01010000
Result:	ALARM

An alarm pattern, for Match or Mismatch, is entered from the keypad as follows:

The bit corresponding with the highest numbered channel in the group is entered first. The bit corresponding with the lowest numbered channel in the group is entered last.

Thus if alarm pattern 00001111 is entered for channels 21 to 28 the bits correspond with the channels as follows:

Selected pattern:	0	0	0	0	1	1	1	1
Corresponding channel numbers:	28	27	26	25	24	23	22	21

Dont care This is a masking facility which allows making any of the bits in an alarm pattern a 'dont-care' state. When any bit is defined as 'dont-care' the detected level (Logic 1 or 0) of the corresponding channel will have no effect on the alarm state, but the level detected will be output at the output device in the normal way. To set up a dont-care state, enter * instead of a 1 or 0.

As the results from all BCD channels are converted to a decimal number, alarm conditions for BCD channels are the same as for analog channels.

4.4 COUNTING AND TOTALIZING EVENTS

In addition to simply responding to individual signal transitions, the logger can count them as well. Count totals are measured and output only when the transition monitoring channel is scanned. Channels that are used to count events must therefore be incorporated in a scanning-type task (as analogue channels).

The SI 3535 can be set up to give two types of event counting as follows:

Totalizing: Produces the cumulative total of transitions since the start of a task, i.e. the total from each new scan is added to the previous total. The maximum count is 65535.

Counting: Produces the total count of transitions since the last reading was produced, i.e. the counter is reset to zero after each scan.

Totals from either type of event counting can have conversion equations applied to give readings in practical units. For example, the total transitions counted over a specified period (as determined by the task scanning rate) could be a count of items observed on a moving conveyor belt. The number of items observed over a 10 second period could be multiplied by 360 to give a rate of 'items per hour'.

4.5 INPUT CONNECTIONS

Inputs are connected via a SI 35301A or a SI 35351C connector (Fig 9.28) as follows:

(a) Contact inputs using the internal floating supply (Fig 9.29).

(b) Contact inputs using an external supply (Fig 9.30).

(c) Outputs from digital instrumentation (Fig 9.31).

4.5.1 Setting Links LK1 to LK20

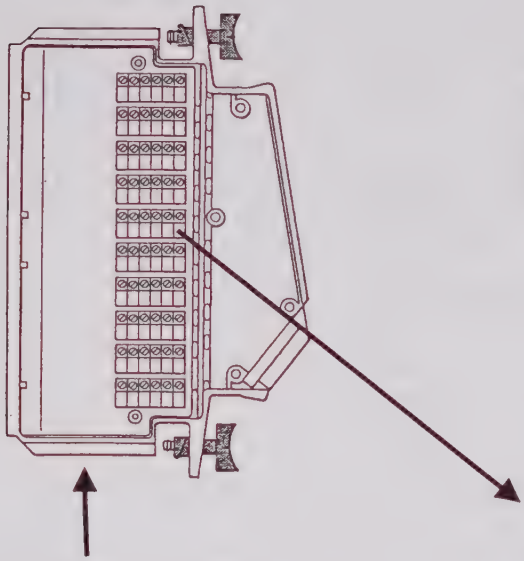
Set links LK1 to LK20 (Fig 9.32) on Event-Status Input Module as required.

NOTE: Each input channel has an associated link which must be set according to the input voltage of each channel: LK1 corresponds with channel 1, or the first of the group of 20 channels; LK2 corresponds with channel 2, etc.

Set links as follows:

input voltage 5V to 12V, link closed;
input voltage 12V to 80V, link open.

Access to the links is gain by removal of the Event-Status Input Module.



INPUT CONNECTOR ASSEMBLY
(COVER PLATE REMOVED)
SI 35303A

H	Hi	see H&L terminals below
L	Lo	
±	5V floating supply	

DIGITAL CHANNELS

1		5V		2	
H	L	-	+	L	H
3				4	
H	L			L	H
5				6	
H	L			L	H
7				8	
H	L			L	H
9				10	
H	L			L	H
11				12	
H	L			L	H
13				14	
H	L			L	H
15				16	
H	L			L	H
17				18	
H	L			L	H
19				20	
H	L			L	H

NUMBERING
Numbering for channels 1-20 only is shown; subsequent sets of 20 channels are similiarly numbered, ie. 21 to 40,41 to 60 and so on, up to 181 to 200.

Channel numbering on any input connector is dependant on which slot it occupies in the logger mainframe.

H & L TERMINALS
For each input channel circuit to conduct, the H terminal must have a +ve potential with respect to the L terminal. When the input circuit conducts the logger gives a measurement of Logic 0. When the input circuit does not conduct the logger gives a measurement of Logic 1.

Note
The 5V floating supply is available only on the pair of terminals between Channels 1 and 2.

Fig 9.29 *Event-status input connector.*

4.5.2 Contact Bounce

Relay and switch contacts often suffer from 'contact bounce' when they are being closed. This effect is unavoidable, but it is generally eliminated by the the filtering circuitry on the Event-Status Input Module. The input circuit for each channel contains a filter which provides immunity against contact-bounce up to approximately 800µs. This is adequate for the majority of applications. If, however, greater immunity is required, an additional capacitor can be fitted to the filter circuit of each or any channel. Each option capacitor should be soldered to a respective pair of pins on the pcb. One pair of pins is provided for each input channel (see Fig 9.33).

Capacitor values for three increased debounce times are:

Capacitor Value	Debounce Time (Approx.)
10nF	1.6ms
22nF	2.5ms
33nF	3.4ms

4.6 INPUT ENERGIZATION

Input energization is required for devices such as switch contacts, relay contacts or outputs from external digital instrumentation. Energization of inputs can be derived from any of the following sources:

(a) The internal 5V supply which provides sufficient current to power all 20 inputs.

(b) An external power supply.

(c) Digital instrumentation, or plant to which the inputs are connected.

All input channels energized by the same supply will have the same common mode voltage. Separate floating supplies must be used for any input, or group of inputs, requiring a different common mode potential.

NOTE: Channels 1 and 2 only must be at the same common mode potential as the internal power supply, i.e. if channel 1 and channel 2 are energized from external plant, one terminal of channels 1 and 2 should be connected to one terminal of the internal supply).

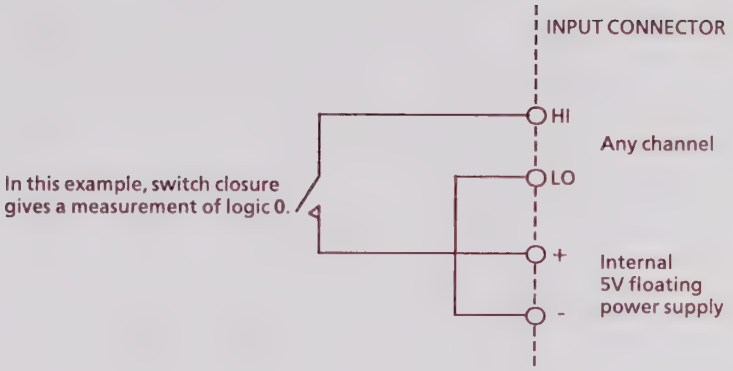


Fig 9.30a *Contact inputs - internal floating supply: single channel.*

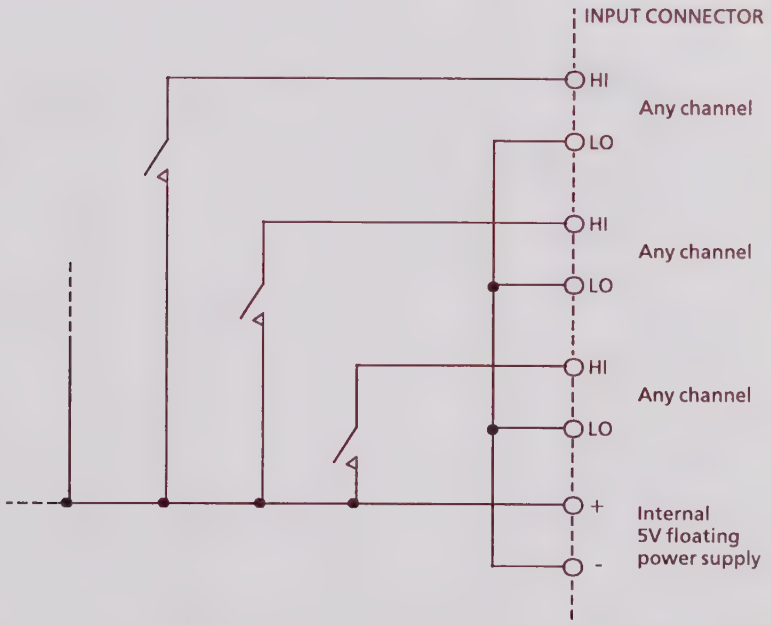


Fig 9.30b *Contact inputs - internal floating supply: up to 20 channels.*

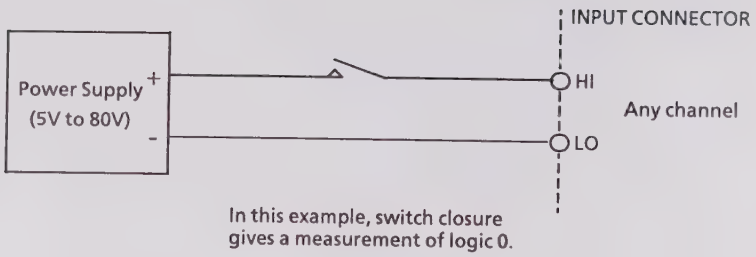


Fig 9.31a *Contact inputs - external floating supply: single channel.*

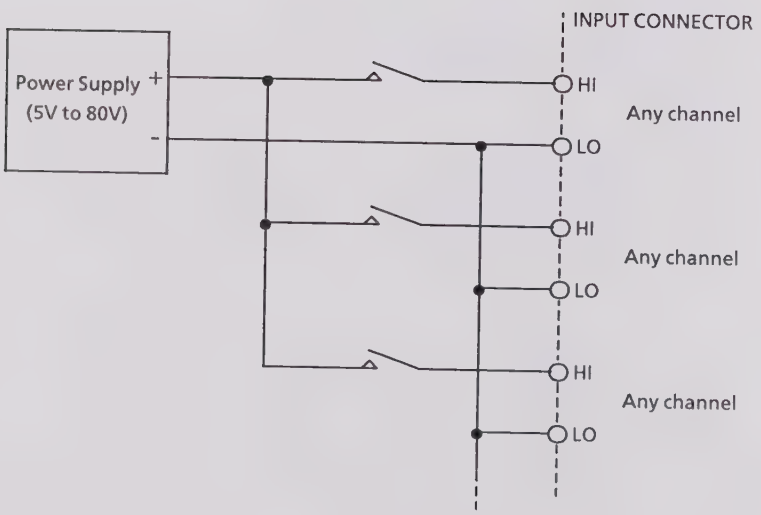


Fig 9.31b *Contact inputs - external floating supply: up to 20 channels.*

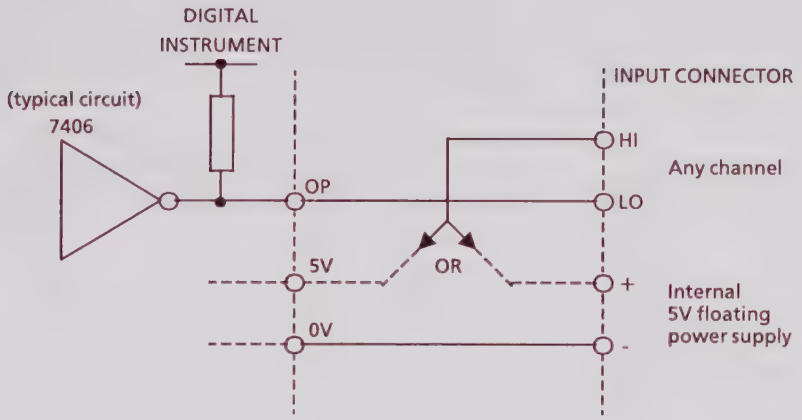


Fig 9.32a *Digital Instrumentation Outputs: single channel.*

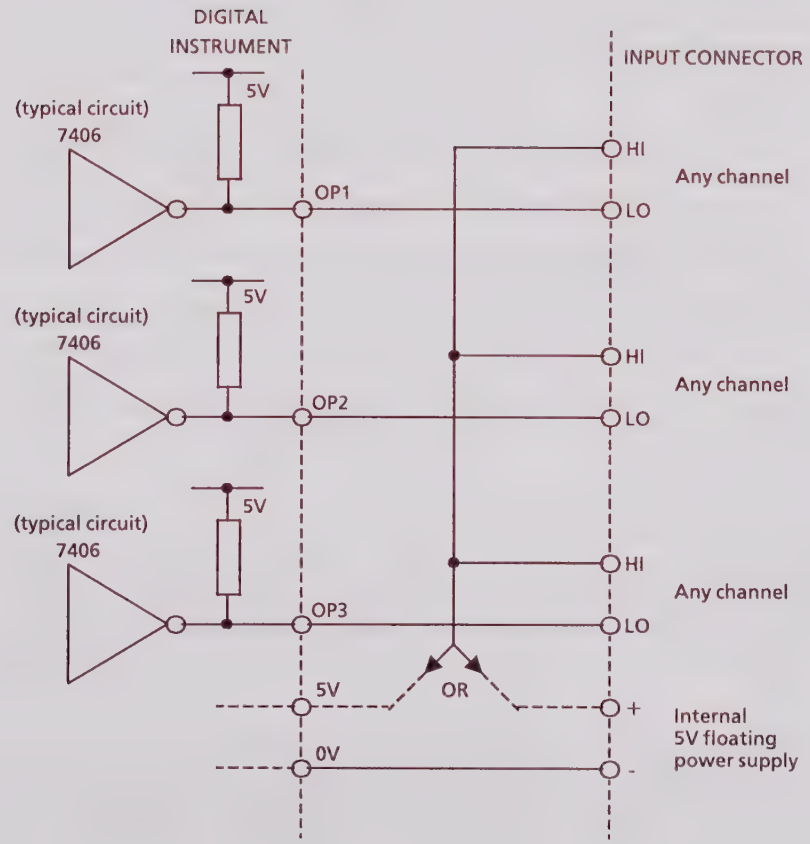


Fig 9.32b *Digital Instrumentation Outputs: up to 20 channels.*

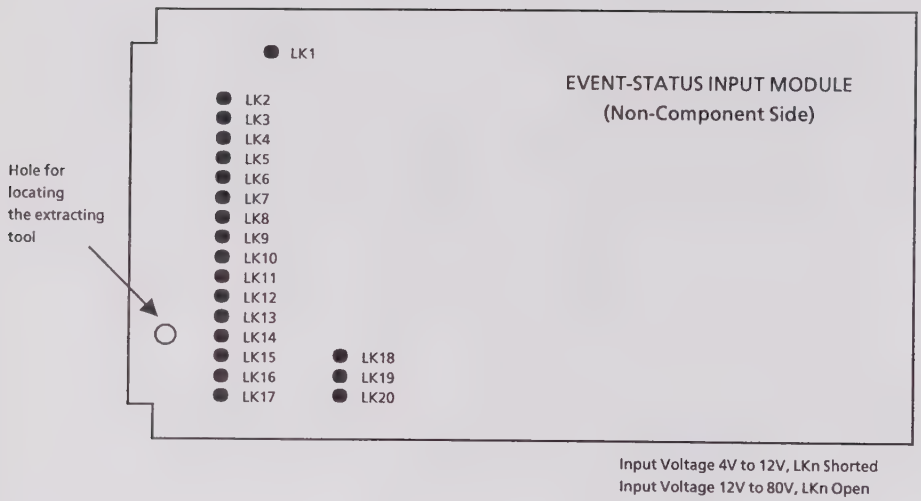


Fig 9.33a *Event-status input module: location of links LK1 to LK20.*

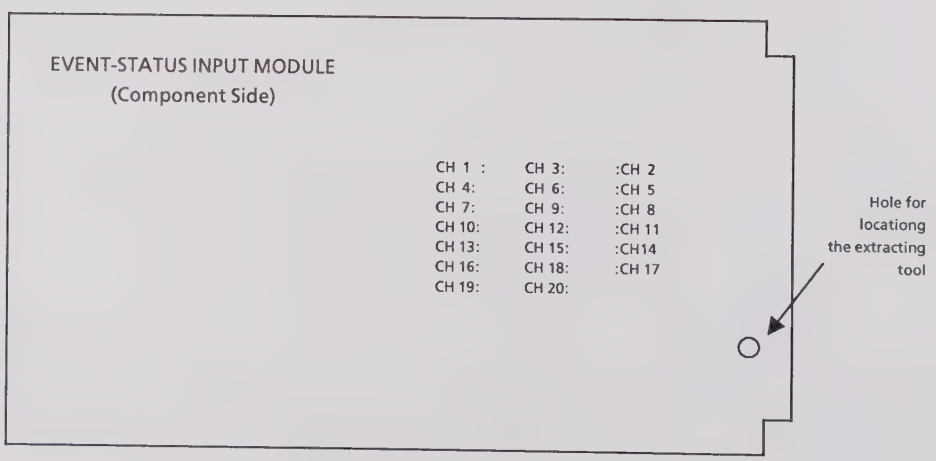


Fig 9.33b *Event-status input module: location of pins for optional filter capacitors.*

5 DIGITAL INPUT-OUTPUT MODULE

The function of each Digital Input-Output Module (SI 35302B) is to provide for 20 input lines and 20 output lines, each with common return (i.e. returns are internally connected to the same point). The logic convention adopted for this module is the same as that described for the Event-Status Input Module (Section 4).

5.1 INPUT/OUTPUT CONFIGURATIONS

The inputs and outputs of the Digital Input-Output Module can be configured in two ways:

(a) Inputs and outputs used independently of each other, with inputs receiving status information and outputs providing alarm/control information.

(b) Inputs and outputs used in conjunction with each other to read in data from other devices, under the supervision of the SI 3535. Address and handshake arrangements are used to co-ordinate the inputs and outputs (Section 5.4).

5.2 TYPES OF INPUT

In general, only status inputs and alarms for status are handled by this module.

The channels specified as status inputs are scanned at the times and intervals defined in a Task, and during scanning the SI 3535 observes the input level (e.g. 0V or 5V). The scanning speed is approximately 500 channels/s with status inputs being used either as individual channels or groups of channels. The logic state displayed for each separate input channel is dependent on the input voltage, i.e:

if > 3.5V logic '0' is displayed; if < 1.5V logic '1' is displayed.

5.3 TYPES OF OUTPUT

The following two distinct types of output are handled by the module:

(a) Alarm outputs (Section 5.3.1) which can be controlled either from alarm conditions detected on analog measurements or from status and event inputs.

(b) Stimuli outputs (Section 5.3.2) which are used to control external switching devices and ancillary control circuitry.

5.3.1 Alarm Outputs

Two alarm channels with quiescent output states at logic '0' can be allocated to any input channel or group of channels. When a low alarm state is detected, the 'Lo' alarm output defined for the input(s) changes to a logic '1' and remains in that state until the low alarm is no longer detected. When a high alarm state is detected the 'Hi' alarm output changes to a logic '1' and remains in that state, until a high alarm is no longer detected.

The same alarm output channel can be used to give an indication of both high and low alarm at the input(s). Or, only one alarm output can be specified and only high or low alarm indicated. Alarm outputs can be reset on Halt, unless this has been disabled (see Reference Manual).

Some alarm conditions such as 'Change' and 'Threshold' are transient. In these cases, the alarm output changes to a logic '1' state when the alarm occurs, and is reset back to logic '0' by the next non-alarm reading on a particular channel. The pulse width of this output can be extended, if required, by connecting external latching circuity to the alarm output.

5.3.2 Stimuli Outputs

Stimuli outputs are similar to alarm outputs, but provide greater flexibility. In a typical application they could be used in groups to produce changing output patterns for control purposes.

Stimuli outputs can be controlled individually or in groups by the processing attached to a Scan Task. When used as a group the outputs form a bit pattern comprising a combination of logic '1's and '0's.

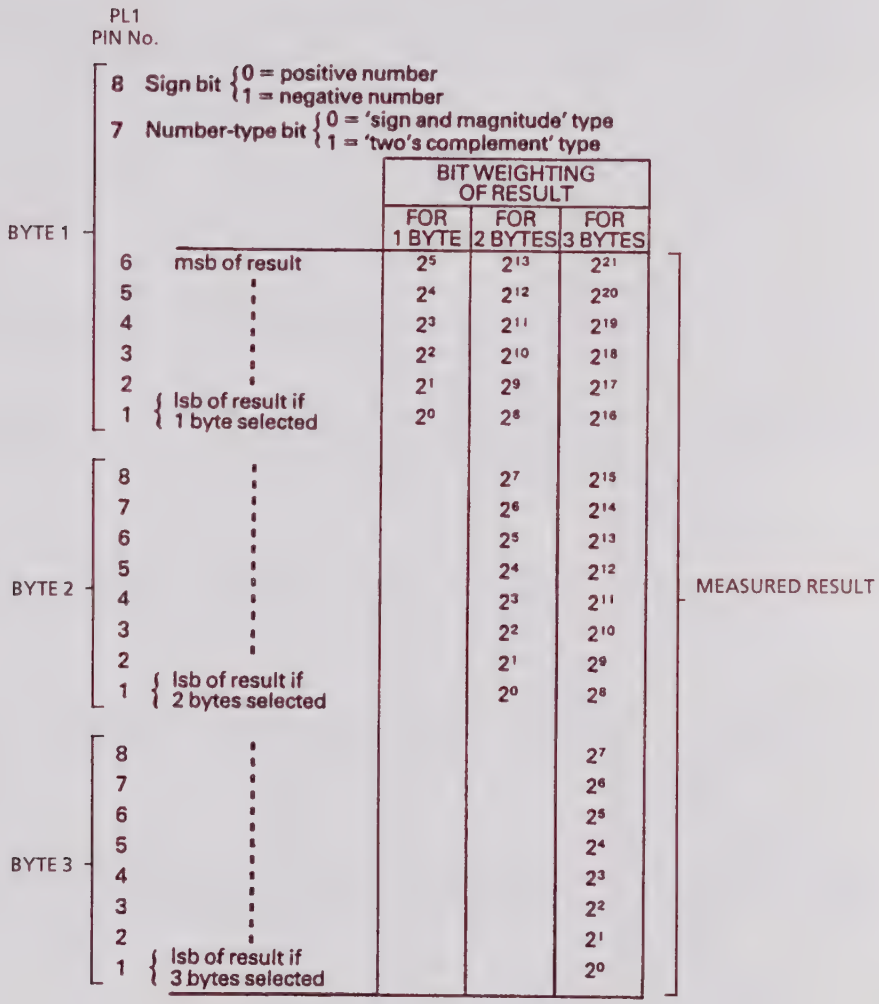
Stimuli outputs can also be controlled remotely, by commands applied through an external control interface. (See SI 3535 Reference Manual, Chapter 3, Section 2.3.3.)

5.4 MEASUREMENTS FROM EXTERNAL MODULES

Inputs and outputs can be combined together to read binary or BCD data from external modules, which include devices such as remote counters and A-to-D converters. The type of external module and corresponding decoding circuitry for a specific application depend on the user requirements.

The input lines on PL1 can read up to 3 bytes of 8-bit binary data (Table 9.2) or 6 BCD decades (Table 9.3) excluding the 'sign' decade. Normal BCD (negative logic) or inverted BCD (positive logic) can be input, selected as part of the Channel Definition. A handshake routine controls data transfer, and digitize command can be provided from the SI 3535 if required. A single SI 35302B module can command up to 20 external modules to digitize data, either simultaneously or sequentially, which is read to the SI 3535.

Table 9.2 Binary Inputs



1, 2 or 3 bytes may be input for each measurement; the bit weighting in each byte varies with the number of bytes selected.

Table 9.3 BCD Inputs

		PL1 PIN No.		BIT WEIGHTING DECADES					
				1	2	3	4	5	6
BYTE 1	Sign decade	8	Sign bit 1 = −ve 0 = +ve						
		7	not used						
		6							
		5							
	1st decade	4	most significant decade	8	80	800	8000	80000	800000
		3		4	40	400	4000	40000	400000
		2		2	20	200	2000	20000	200000
		1		1	10	100	1000	10000	100000
BYTE 2	2nd decade	8			8	80	800	8000	80000
		7			4	40	400	4000	40000
		6			2	20	200	2000	20000
		5			1	10	100	1000	10000
	3rd decade	4				8	80	800	8000
		3				4	40	400	4000
		2				2	20	200	2000
		1				1	10	100	1000
BYTE 3	4th decade	8					8	80	800
		7					4	40	400
		6					2	20	200
		5					1	10	100
	5th decade	4						8	80
		3						4	40
		2						2	20
		1						1	10
BYTE 4	6th decade	8							8
		7							4
		6							2
		5							1
	7th decade	4							
		3							
		2	(Not used)						
		1							

Any number of bcd decades between 1 and 6, excluding the Sign decade, may be input for each measurement: the bit weighting in each decade varies with the number of decades selected. The decades are read in pairs, in up to 4 bytes.

5.4.1 External Modules - Typical Application

A configuration using one set of 10 inputs and 10 outputs (Fig 9.34) is used to read the digitized output from a 14-bit analogue-to-digital converter. The 14 output lines are connected to two 8-line latches, which can be selected independently, allowing 14 outputs to be read in 2 binary bytes (8 lines and 6 lines).

Digital inputs 1 to 8 comprise one channel, designated as Channel 1. The 14-bit analogue-to-digital converter (external module) is addressed by the module address output. The external address decoder is enabled by the Address Valid output (Output 10) to a logic '1' state. The Byte Output is set to byte 1, causing one of the external latches to be enabled ready for the first data byte.

The digitize command signal, comprising a 10μs positive-going pulse at output 9, is produced when all outputs 1-8 are stable. The A-to-D converter then starts reading, and digitizes the analogue input using sample and hold.

On completion of the measurement the external module outputs a positive-going digitize complete signal. This is input on PL1 input 10, to indicate that data is ready for reading. The SI 3535 then reads in the first byte at inputs 1-8.

The Byte Selected output then selects byte 2, causing the other latch to be enabled ready for the SI 3535 to read the second byte. When the outputs have settled, the Address Valid output becomes logic '1' and the SI 3535 reads the second byte at input 1-6.

5.5 ALARMS FOR STATUS INPUTS

The information for setting up alarms for both single channels and grouped channels is identical to that used for the Event-Status Module. (See Section 4.3 in this chapter.)

5.6 INPUT-OUTPUT CONNECTIONS AND CHANNEL ALLOCATION

The inputs and outputs are connected to the sub-miniature D-type connectors PL1 and PL2. The 20 inputs and 20 outputs are grouped as two sets of 10 inputs and 10 outputs (Table 9.4).

Outputs 1-10 and Inputs 1-10 are located on PL1; Outputs 11-20 and Inputs 11-20 are located on PL2. Note that, although the inputs and outputs are referred to as '1-20', the actual numbering depends on the location of the Digital Input-Output Module in the SI 3535 backplane.

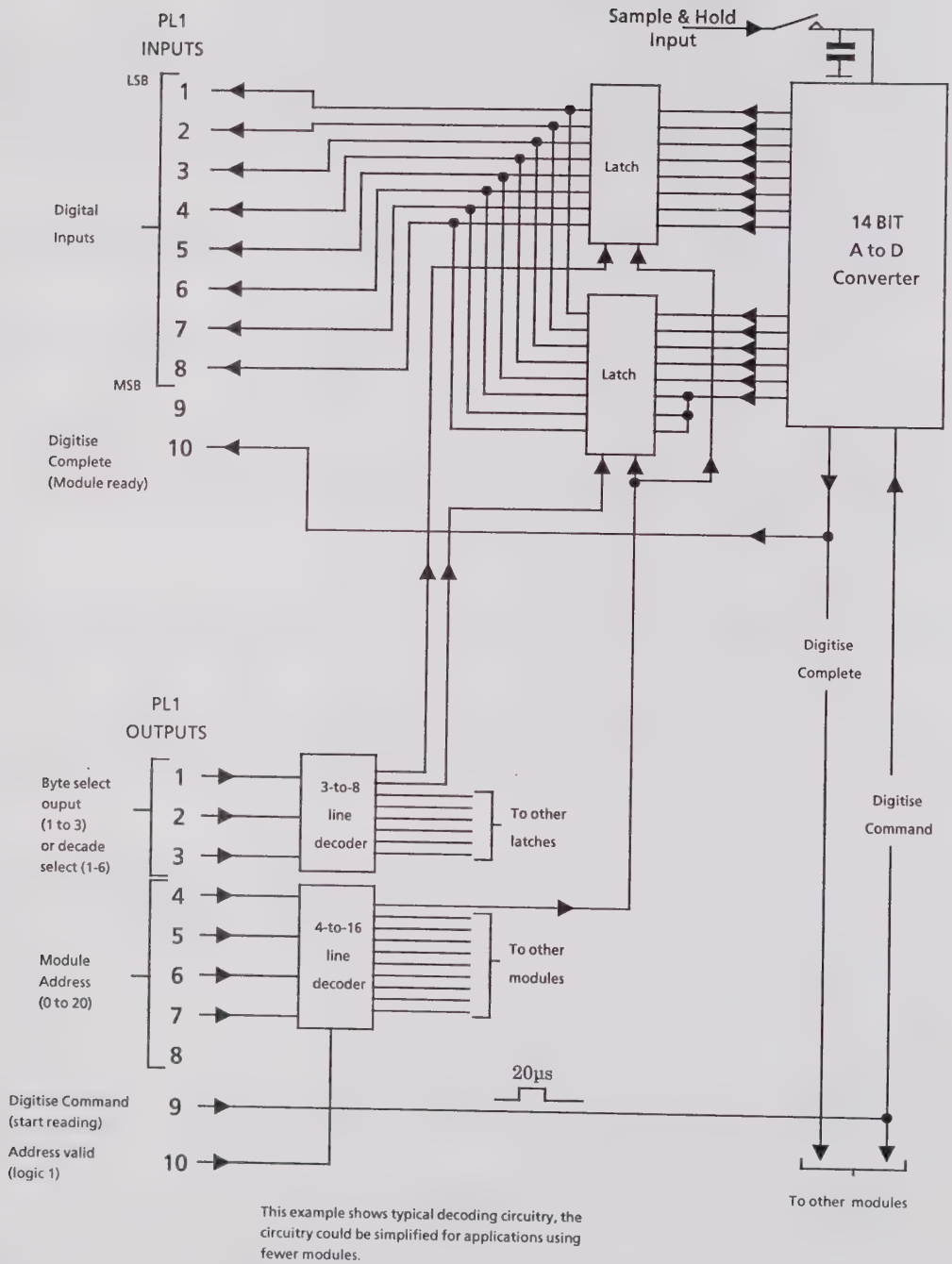
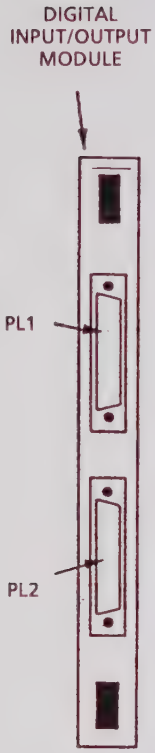


Fig 9.34 *External measurement modules - typical connections.*

Table 9.4 Digital Input-Output PL1/PL2 Pin Assignment



PL1 and PL2 Pin Numbering

PL1

Pin No.	Signal	
1	Vu	
2	0Vf	
3	O1	OUTPUTS
4	O2	
5	O3	
6	O4	
7	O5	
8	O6	
9	O7	
10	O8	
11	O9	
12	O10	
13		
14	0Vf	
15	I1	INPUTS
16	I2	
17	I3	
18	I4	
19	I5	
20	I6	
21	I7	
22	I8	
23	I9	
24	I10	
25		

PL2

Pin No.	Signal	
1	Vu	
2	0Vf	
3	O11	OUTPUTS
4	O12	
5	O13	
6	O14	
7	O15	
8	O16	
9	O17	
10	O18	
11	O19	
12	O20	
13		
14	0Vf	
15	I11	INPUTS
16	I12	
17	I13	
18	I14	
19	I15	
20	I16	
21	I17	
22	I18	
23	I19	
24	I20	
25		

NOTE: It is permissible to connect status inputs to the input channels and a mixture of alarm and stimuli outputs to the output channels, but is not permissible to connect any of these inputs or outputs to PL1 if it is being used for external module measurement (Section 5.4).

5.6.1 Connecting Inputs

The status inputs are activated by a logic '1' or logic '0' input voltage. This can be sourced from a switch and an external supply voltage. (The logger does not supply energization for the status inputs.) TTL-compatible semi-conductor switches or relay contacts can be used to switch the supply. The connection details (Fig 9.35) apply equally to status inputs and the inputs in external module measurement.

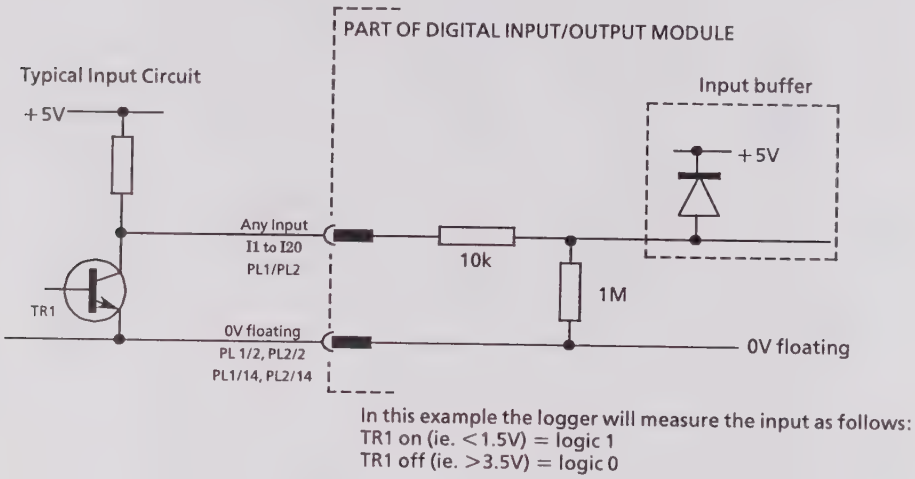


Fig 9.35 *Digital input-output, typical input configuration.*

5.6.2 Connecting Outputs

The digital outputs can be configured for one of three different type of electrical arrangement (Fig 9.37) regardless of whether the outputs are dedicated to alarm stimuli or external module measurement. The three configurations are:

(a) TTL/CMOS compatible outputs, using the internal floating 5V supply.

(b) Outputs with 4.7k 'pull-up' resistors to an external supply voltage.

(c) Open-drain (FET) outputs using an external supply.

Selection of (a), (b) or (c), which commits all 20 outputs to the same configuration is achieved by appropriate connection of links P1-P5 on the module (Fig 9.36). Connect all outputs as shown in Fig 9.37 as appropriate, corresponding with the type of linking (P1-5) selected. Make connections with the sub-miniature D-type plug supplied: this mates with PL1/PL2.

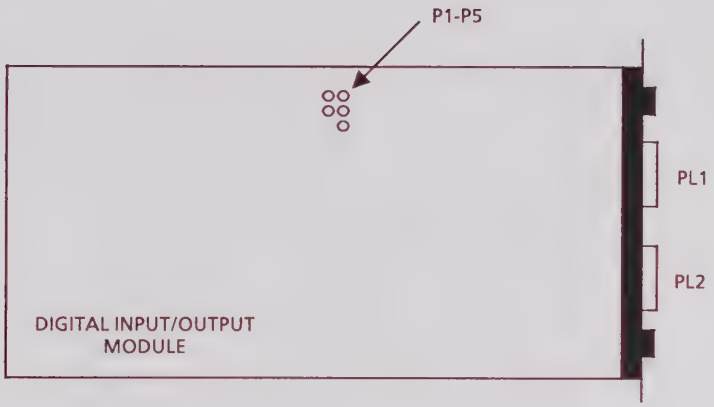


Fig 9.36 *Location of pins P1 to P5 on digital input/output module.*

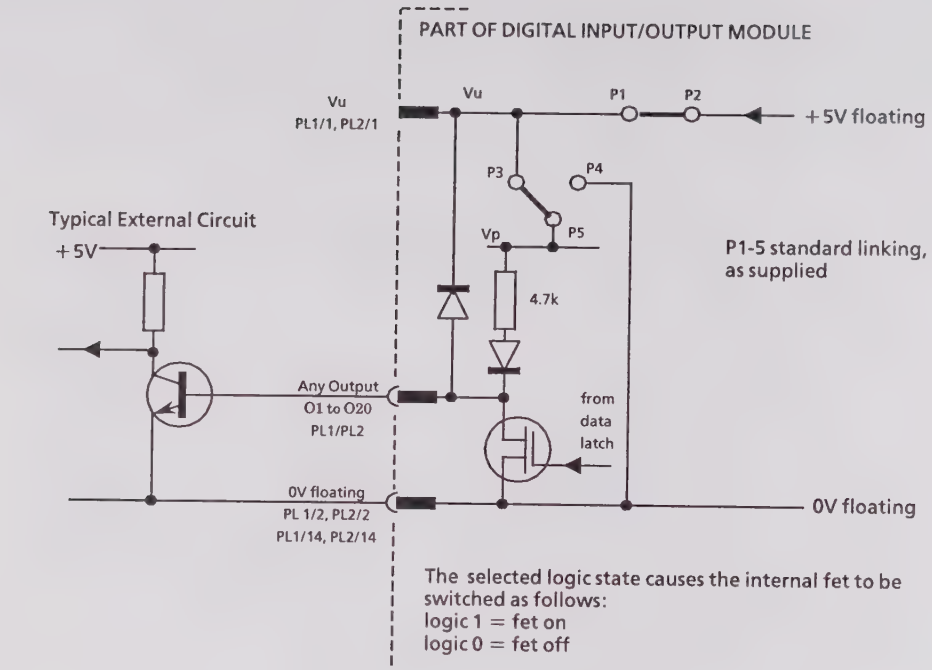


Fig 9.37a *Digital input-output configurations: TTL compatible outputs.*

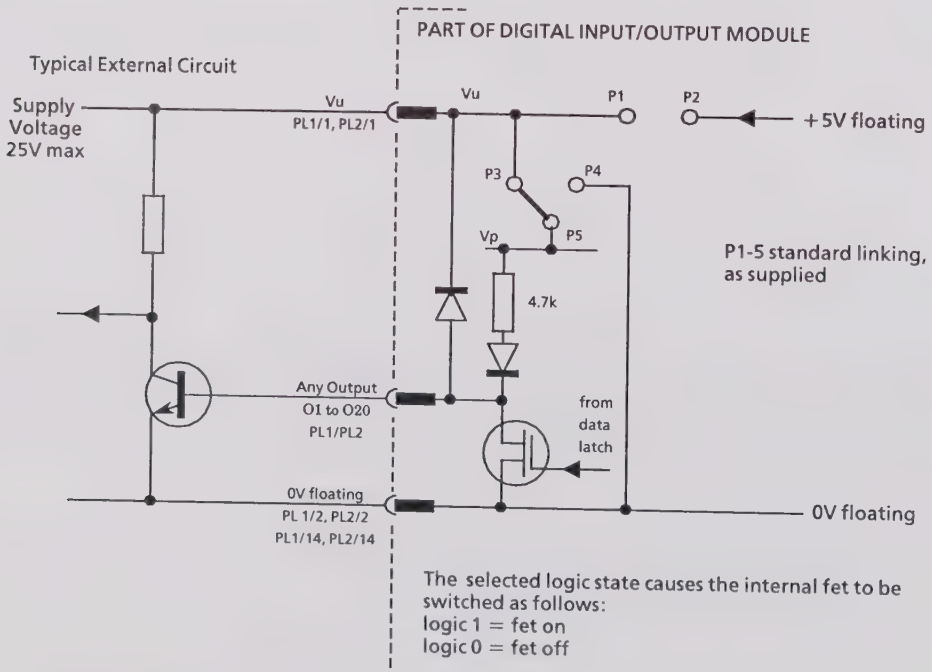


Fig 9.37b *Digital input-output configurations: outputs with 4.7k pull-up resistors.*

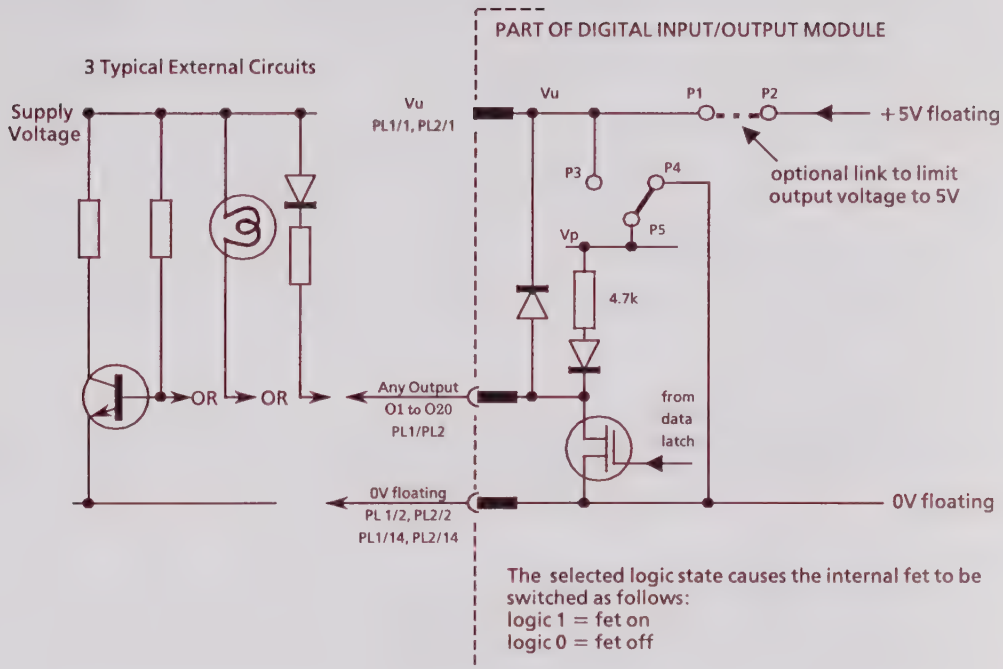


Fig 9.37c *Digital input-output configurations: open drain (FET) outputs.*

6 COUNTER TIMER MODULE

6.1 PARAMETERS MEASURED

The Counter Timer Module (SI 35302C) allows measurement of any of the following parameters, on any one of five input channels:

(a) Signal frequency,

(b) Signal time period,

(c) Totalized pulse count,

(d) Interval pulse width.

The preferred location for a Counter Timer module is slot number 4 of the SI 3535 backplane.

6.2 MEASUREMENT TECHNIQUES

A brief description is given, in Sections 6.2.1 through 6.2.4, of the techniques used to measure each type of parameter handled by the Counter Timer.

6.2.1 Signal Frequency

Signal frequencies of up to 400 kHz are measured by averaging the result over a selected gating time (Fig 9.38a) which can be selected as Internal or External. For internal gating, the gate times can be selected as 0.1, 1, 10 or 100 seconds. Alternatively, external gating pulses of any duration up to 600 seconds can be input at terminal G.

Short gate times are generally used for the measurement of high frequencies. Long gate times are used either for the measurement of low frequencies or for maximum measurement accuracy at any frequency.

With the SI 3535 in RUN mode, measurements begin when a gate signal is applied, but results are only output during a Scan period.

NOTE: The Monitor facility can be used to obtain each result as it becomes available. However, if the SI 3535 is in the HALT state, Monitor causes measurements to start when a gate signal is applied, in a similar way to that for RUN.

Fig 9.38b shows a frequency input signal, and a gating signal which is generated internally (i.e. 0.1, 1.0, 10 or 100 seconds). Following a RUN command, gating pulses are produced automatically, and are repeated with a 1 second delay between each pulse. The derived reading comprises the average frequency, measured over the last completed gate time.

If the first gate time has not been completed before a Scan occurs, the WAIT message is output. The six typical scans shown in Fig 9.38b produce the following results:

Scan 1 WAIT, no result ready yet
Scan 2 *a* Hz, as measured during gate time *a*
Scan 3 *a* Hz, since no further gate time has occurred
Scan 4 *b* Hz, as measured during gate time *b*
Scan 5 *e* Hz, as this was the latest measurement available
Scan 6 WAIT, since the RUN command effectively resets the frequency and no new gate time has yet been completed.

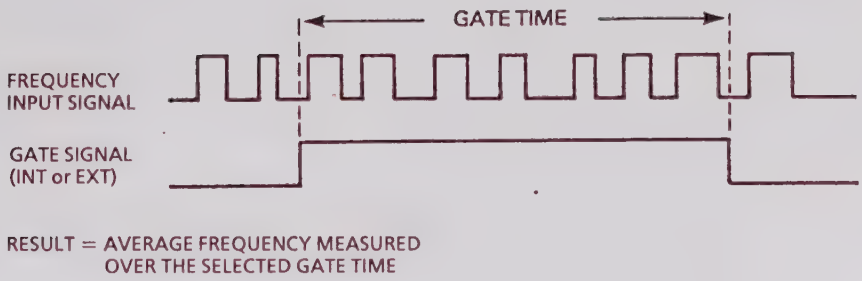


Fig 9.38 (a) *Counter timer, frequency measurement: frequency input signal.*

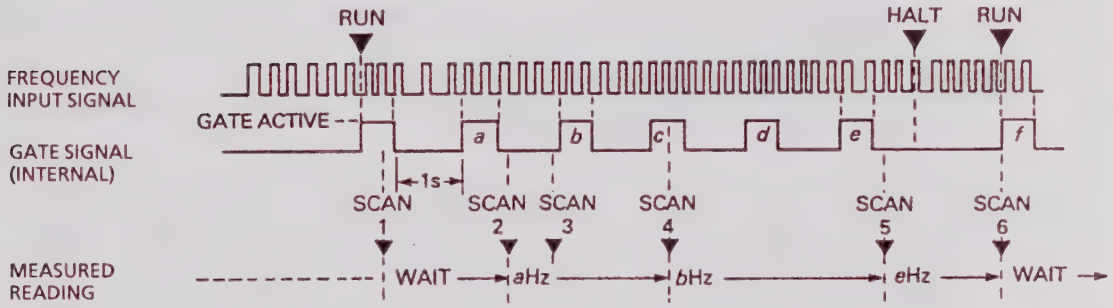


Fig 9.38 (b) *Counter timer, frequency measurement: internal gating signal.*

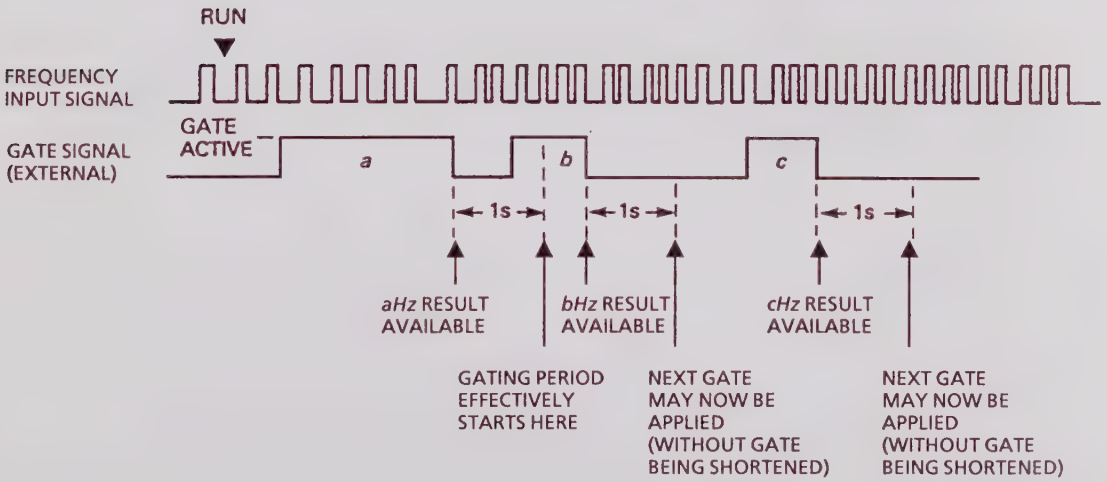


Fig 9.38 (c) *Counter timer, frequency measurement: external gating signal.*

On HALT the gate pulses stop, and on RUN the result is reset and measurement re-starts. When a frequency measurement is completed the start of a new measurement is delayed by one second: this applies for both external and internal gating.

When using external gating, allow an interval of at least one second between each pulse, to avoid the gate time being shortened. Also, ensure that each gate pulse occurs, and is completed, before a Scan.

NOTE: If external gating is applied for a specific time period, and then re-applied within one second, the part of the second gate signal occurring during the one second interval is ignored. This second gating signal produces a normal frequency measurement, which is started immediately after the one second interval.

Synchronization between the end of a gate pulse and a Scan is obtained with the following procedure (see Fig 9.39):

1. Connect the gating signal to the G+ and G – inputs on the Counter Timer Module and to an Event channel on an Event-Status Input Module.

2. Include the Event channel in an Event Task, and program this Task to trigger the Scanning Task that is used to measure frequency.

It should be noted that an external gate actually operates in conjunction with an internal clock signal that runs at 100 Hz. Hence, when the external gate is used, the actual gate time will be rounded up to the next internal clock edge. As a result of this, the following conditions apply:

(a) The gate may open later than the external gate by up to 10 ms.

(b) The gate may last longer than the external gate by up to 10 ms.

This effectively limits the external gate time to greater than 10 ms. However, this does not affect the measurement accuracy, since the actual gate time is always used in the frequency calculation.

The frequency measurement function is not suitable for very low input frequencies, since a large error can result if the frequency is very low with respect to the gate time. It is suggested that the Signal Time Period facility (Section 6.2.2) is used for the accurate measurement of low frequencies.

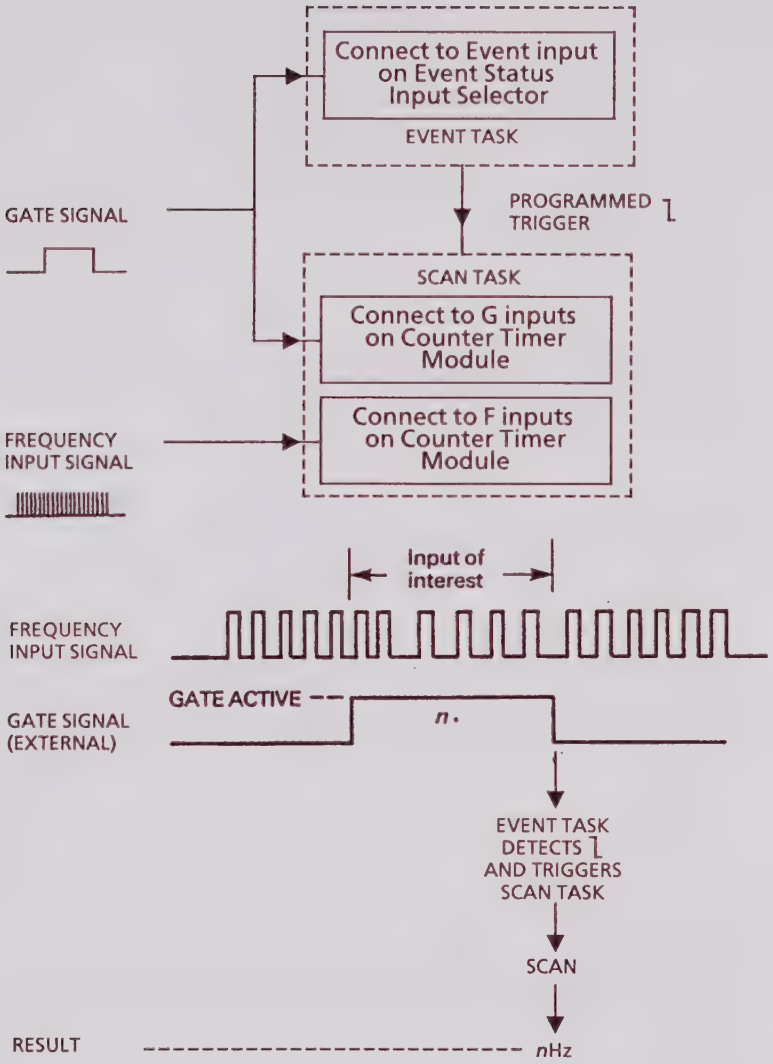


Fig 9.39 *Synchronisation of scan and gate pulses.*

6.2.2 Signal Time Period

To measure a signal time period, an average period is derived by counting a selected number of input periods, measuring the elapsed time, and dividing this time by the number of periods. Higher accuracy is achieved by making measurements over a higher number of periods. The selectable number of periods is 1, 10, 100, 1000 or 10,000 periods. The period length, defined as the time taken to count n periods (selectable number) must be in the range 500ms to 60 minutes.

The example in Fig 9.40a shows a period input, for which 10 periods are selected. The time taken for these 10 periods is measured, and divided by 10 to produce the result. Measurements are repetitive at one second intervals.

A further example (Fig 9.40b) shows the selected number of periods as n, where n can be any of the selectable values. Each result is available at the end of each respective measurement, and is retained until the next measurement has finished. However, it should be noted:

(a) If a measurement is halted before *n* periods have occurred, no result is gained from the measurement.

(b) Entering RUN resets any existing results, and restarts the measurement process.

(c) Once a period measurement is completed, a new measurement will not be started until one second has elapsed.

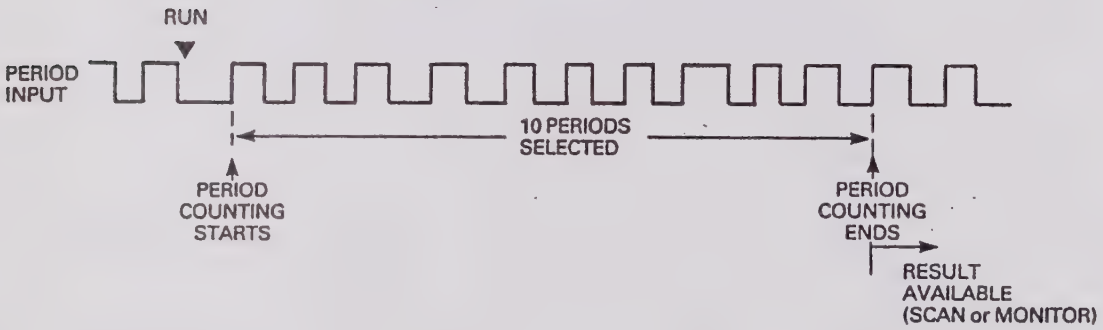


Fig 9.40 (a) *Signal time period measurement: ten periods.*

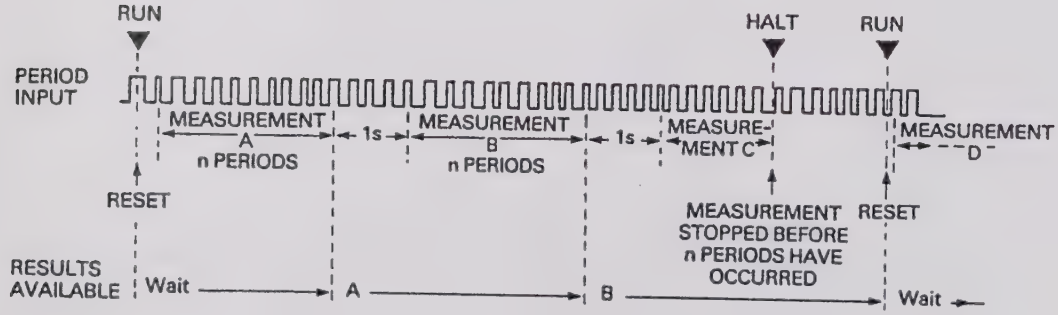


Fig 9.40 (b) *Signal time period measurement: 'n' periods.*

The Period measurement function should not be used to measure very short periods over a low number of periods, since this could result in poor accuracy. Consider an input period of 2.5 µs (= 400 kHz) measured over one period. Since the SI 3535 measures a period to an accuracy of approximately 1µs, this represents a very large proportion of the time to be measured and a large measurement error can be expected. To improve accuracy, it is suggested that the signal is measured over a large number of periods (e.g. 10,000), or that the frequency facility is used instead of Period. The frequency (Hz) result obtained can then be converted to period using the formula:

$$\text{Period (seconds)} = 1/\text{frequency (Hz)}$$

The Conversion facility can be used to achieve this automatically, resulting in a highly accurate measurement of the short period.

6.2.3 Totalized Pulse Count

A count of pulses that occurred while the gate was enabled can be produced (Fig 9.41). Following RUN command, the counter is reset to zero and counting commences when a gating signal is applied. When the gating signal is removed counting stops and the result is frozen. If the gating signal is again applied the counter is reset and counting re- commences. When a Scan occurs, the running total or final total is displayed and the counter is reset whenever RUN is selected.

The Monitor facility can also be used to give a Totalize result. If the logger is in RUN, the Monitor produces the running total or final total. If the logger is in HALT, the monitor resets the counter, counting restarts (assuming the gate signal is present) and the running total is then shown.

It is preferable that the gate inputs are switched using electronic switches. If electro-mechanical switches are used they must be made bounce-free, possibly by the use of a filter capacitor, since a make or break with a multiple bounce can cause the count to be erroneously reset.

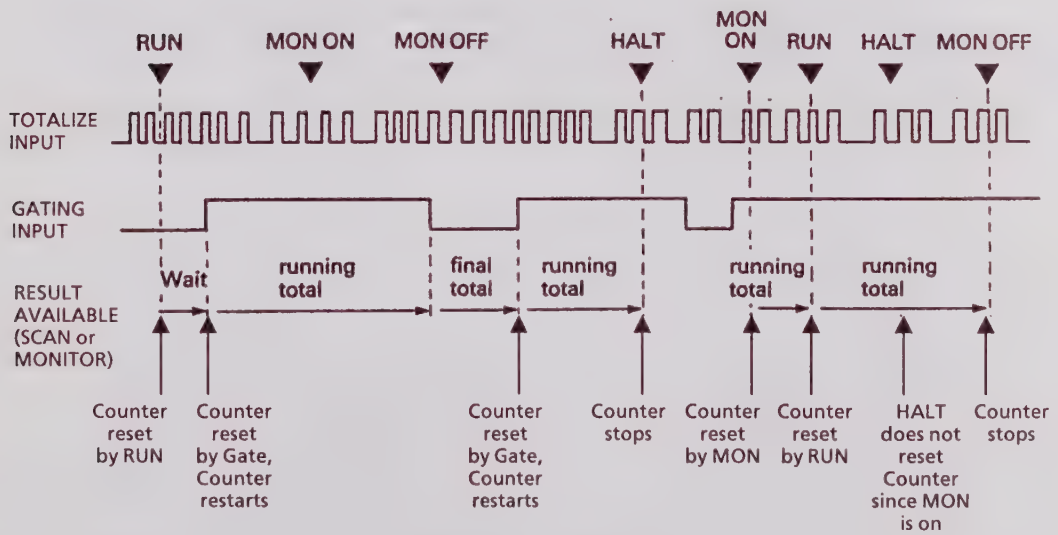


Fig 9.41 *Totalised pulse count measurement.*

6.2.4 Interval Pulse Width

Interval pulse widths are measured using Active Hi input connections between a positive transition and the next negative transition (Fig 9.42a) or using Active Lo input connections between a negative transition and the next positive transition (Fig 9.42b). It is possible to measure interval times within the range 500 µs to 60 min.

Following each interval pulse, a minimum time must elapse before another interval pulse can be applied to any channel. This includes all active Counter Timer channels and all active Event channels on an Event Status Module. The time allowed between interval pulses is defined as follows:

$$\text{Time} = 2\text{ms} \times n$$

where n is the total number of counter timer and event channels within the SI 3535 that are in use, e.g. for five channels allow 10ms.

The elapsed time between interval pulses allows the processor to service any interrupts which active channels may generate. If adequate time is not allowed between any two interval pulses the result from the first pulse is lost.

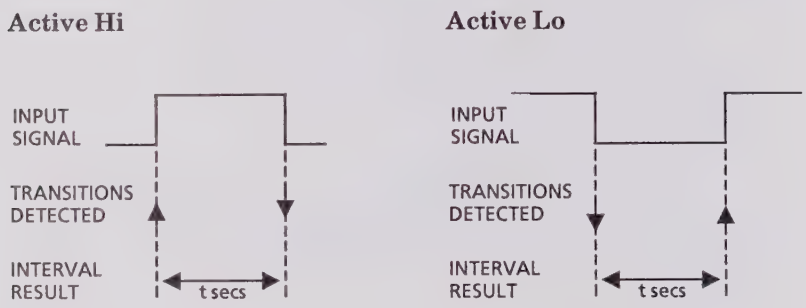


Fig 9.42 (a) *Interval pulse width measurement: active Hi and active Lo.*

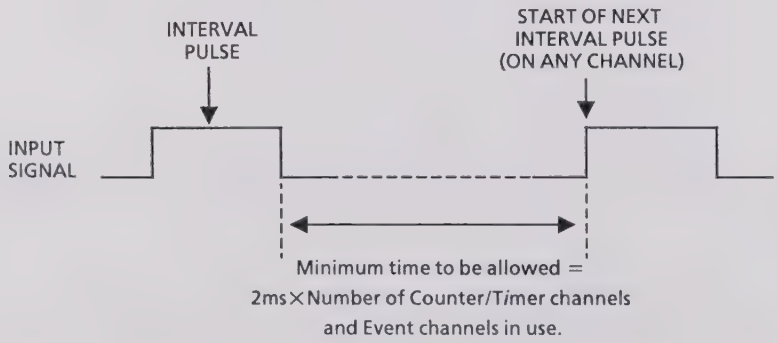

INTERVAL PULSE
START OF NEXT INTERVAL PULSE (ON ANY CHANNEL)
INPUT SIGNAL
Minimum time to be allowed =
2ms × Number of Counter/Timer channels and Event channels in use.

Fig 9.42 (b) *Interval pulse width measurement: minimum interval time.*

6.3 MAKING MEASUREMENTS

The Counter Timer channels are active only when the SI 3535 is in RUN, or when Monitor is ON. Corresponding results are acquired by scanning in RUN, or monitoring in RUN or HALT.

A Channel Definition is set up for each Counter Timer channel, and these channels are incorporated into a task using Task Definition. Monitored results are derived using the Monitor facility.

Two commands reset the results from all counter timer channels:

(a) RUN command

(b) Monitor On command (if the SI 3535 is in HALT).

Measurement restarts immediately after reset.

6.4 MONITOR OPERATION

With the SI 3535 in the HALT state, measurement starts when Monitor is switched on and a gating signal is present. A WAIT message is output until the first measurement result is available. Measurements then continue until monitor is switched off. Each result is maintained until the next one is available, from result to result.

Selecting RUN, whilst Monitor is on, resets the present result and restarts measurement. A 'Wait' message is displayed until a further message becomes available.

Selecting Monitor, whilst the SI 3535 in the RUN state, outputs the most recent result. Further results are output as they become available.

Measurements are started by the RUN command, and are not affected when Monitor is switched on or off.

6.5 INPUT CONNECTIONS AND SWITCH SETTINGS

Each of the five channels of a Counter Timer Module use two pairs of inputs: F+, F–, and G+, G–. Both pairs can be used for each channel, depending on the measurement selected. The inputs to be used for each of the four measurement functions are indicated in Table 9.5.

Table 9.5 Measurement Function Inputs

Measurement Function	F Inputs	G Inputs
Frequency	Frequency Signal	External gating signal
Period	Period Signal	Not used
Totalize	Totalize Signal	Gating Signal
Interval	Not used	Interval Signal

All input connections to the Counter Timer Module are made via PL1, as shown in Table 9.6.

Switches 1 to 5 (Fig 9.43) on the Counter/Timer pcb correspond to Channels 1 to 5 respectively and determine the bias conditions in the input circuit. Each switch should be set for the type of input connected to its particular channel, as shown in Figs 9.48 through 9.51. Two wafers of each switch set up the G input, and two wafers set up the F input; these can be set independently of each other, to correspond with the Active Hi or Active Lo input circuit (Fig 9.44).

Connection details for differential and TTL inputs (i.e. Active Hi and Active Lo for each) are shown in Figs 9.45 through 9.48.

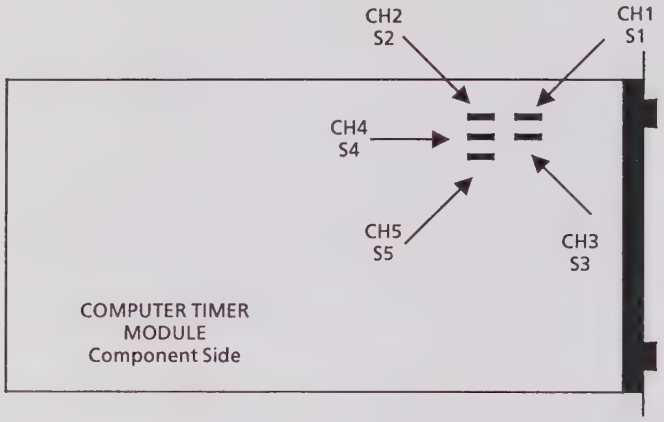


Fig 9.43 *Location of switches S1 to S5 on counter timer module.*

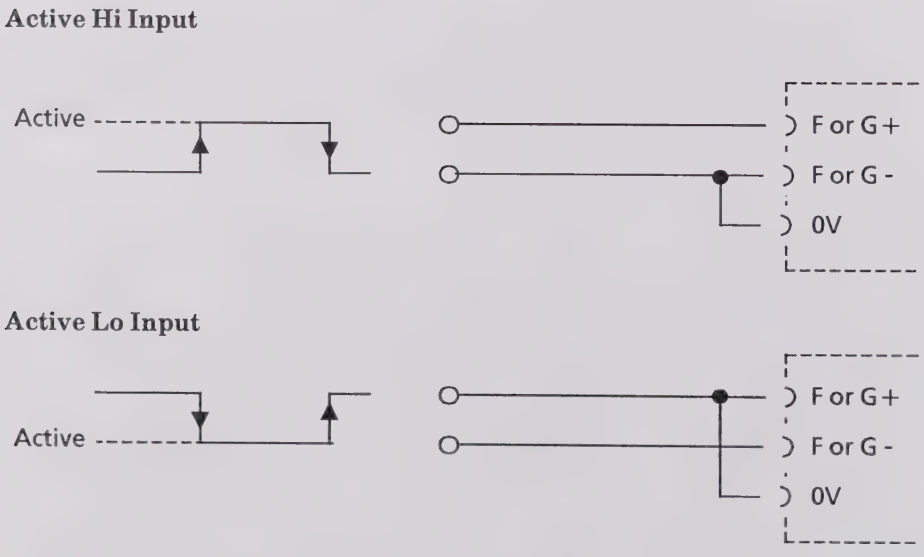
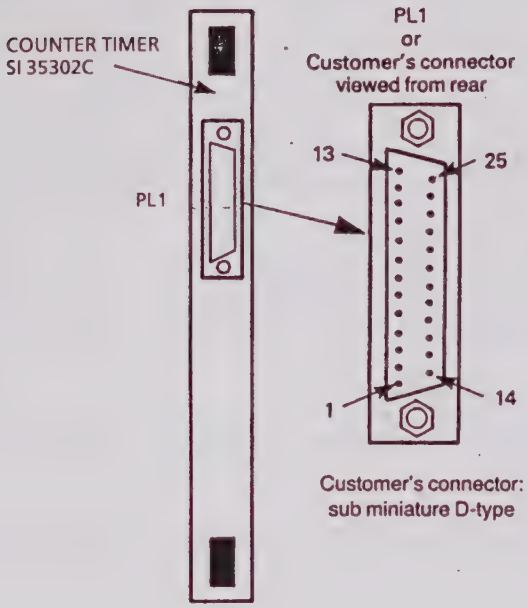


Fig 9.44 *Active Hi and active Lo inputs on counter timer module.*

Table 9.6 Counter Timer PL1 Connections



Pin No.	Signal
1	F1-
2	G1-
3	F2-
4	G2-
5	F3-
6	G3-
7	F4-
8	G4-
9	F5-
10	G5-
11	+19V
12	0V
13	0V19
14	F1+
15	G1+
16	F2+
17	G2+
18	F3+
19	G3+
20	F4+
21	G4+
22	F5+
23	G5+
24	-30V*
25	+12V*

*For test purposes only

6.5.1 Connection Procedure

1. Using a 25-way sub-miniature D-type connector that mates with PL1, connect the inputs as indicated:

   For differential inputs, active Hi, see Fig 9.45.
   For differential inputs, active Lo, see Fig 9.46.
   For TTL inputs, active Hi, see Fig 9.47.
   For TTL inputs, active Lo, see Fig 9.48.

   Check that the F and G inputs for each channel are correctly used for the measurement function required. (See preliminary information in Section 6.5.)

   When measuring high frequency signals, keep connecting leads as short as possible. If long leads are used, the effects of cable capacitance and source impedance may degrade the signal and effect the pulse timing.

2. With the SI 3535 switched off, remove the Counter Timer Module from the mainframe.

3. Set switches S1 through S5 to correspond with the signals being connected; the switch locations are shown in Fig 9.43.

4. Refit the Module in the mainframe and fit the sub-miniature D-type connector to PL1.

5. With the SI 3535 switched on, select the Program Menu (Chap 5) and set up the counter timer channels as required.

See notes on next page.

Note 1: The channel numbers for a Counter Timer Module are:

1 to 5, if fitted in Slot 4
21 to 25, if fitted in Slot 5

↓

181 to 185, if fitted in Slot 13.

Note 2: Switch off the counter timer channel scanning when not in use.

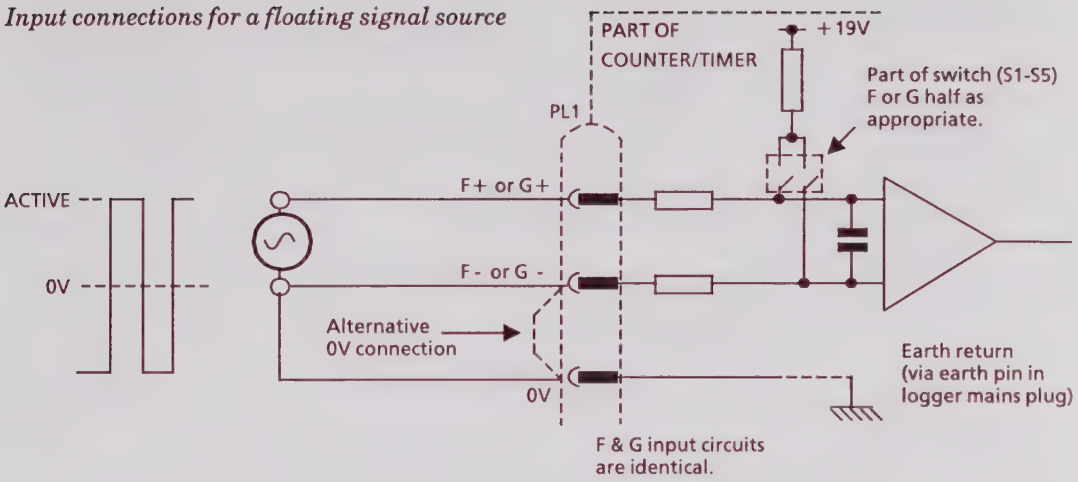
6.6 TRANSDUCER ENERGIZATION

The SI 3535 24V supply is accessible at PL1 pin 11 as a source for energizing transducers; a maximum current of 250 mA can be drawn for one Counter Timer Module.

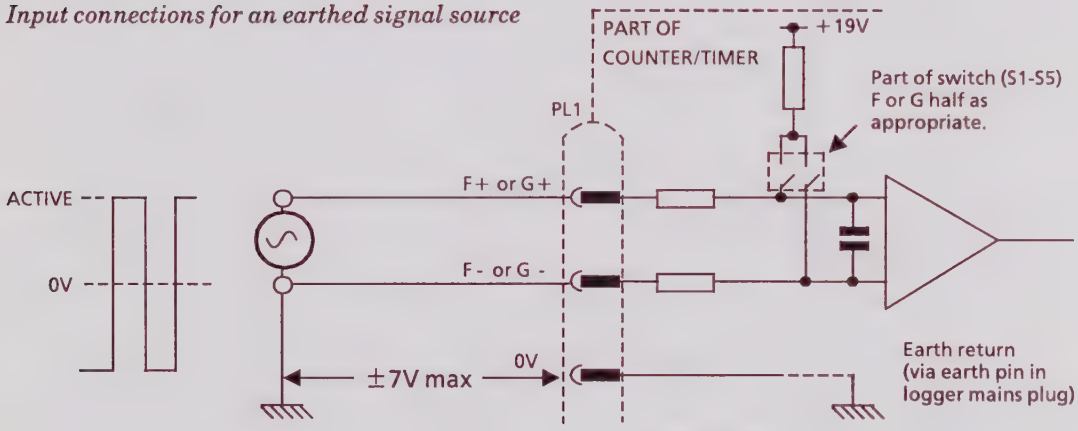
Note1: The transducer energization facility provided by the Counter Timer Module is totally independent of the actual Transducer Energization Module (TEM) used with the analog selectors.

Note2: The current drawn from the 24V supply via the TEM and counter-timers must not exceed 1A in total.

Input connections for a floating signal source

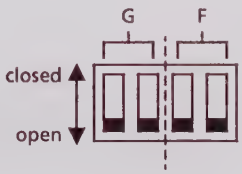


Input connections for an earthed signal source



NB The earth return (via earth pin in logger mains plug) is essential when no 0V connection is made.

S1 to S5 Settings (for floating or earthed signal source)

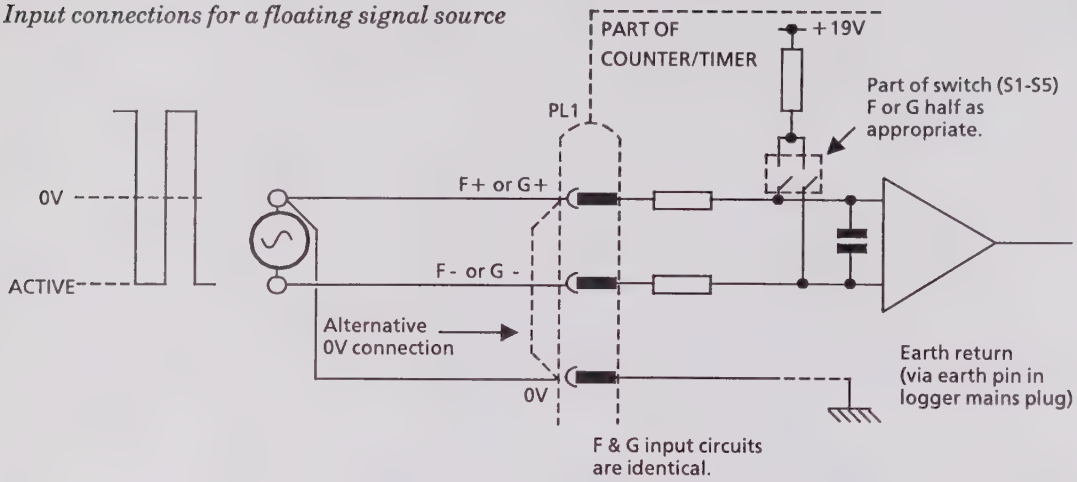


S1 to S5 relate to Channels 1 to 5 respectively.

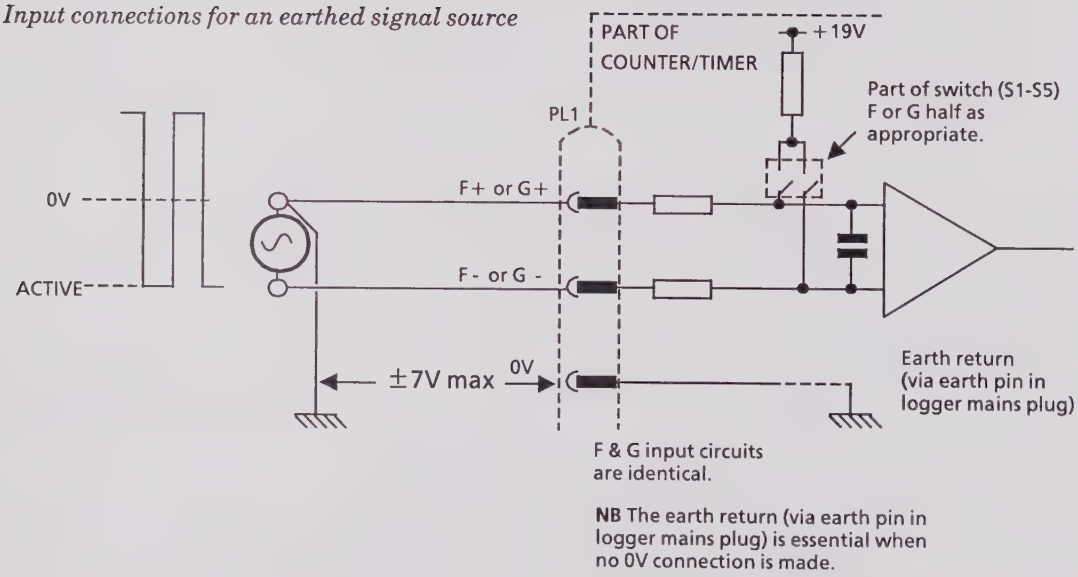
The F and G switches are shown set for differential input. F and G switches may be set independently for differential or TTL, as required.

Fig 9.45 *Differential inputs - active Hi.*

Input connections for a floating signal source



Input connections for an earthed signal source



NB The earth return (via earth pin in logger mains plug) is essential when no 0V connection is made.

S1 to S5 Settings (for floating or earthed signal source)

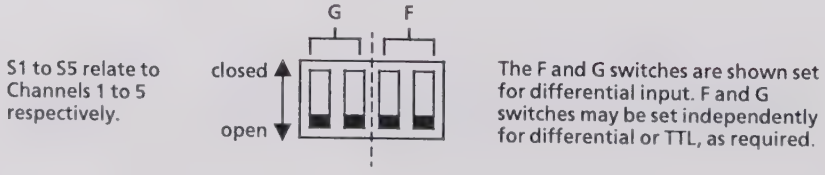
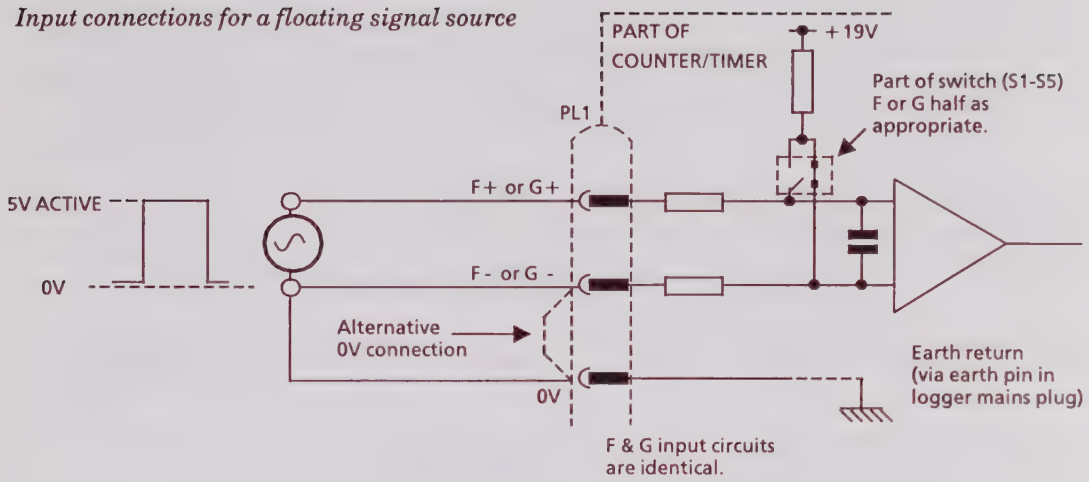
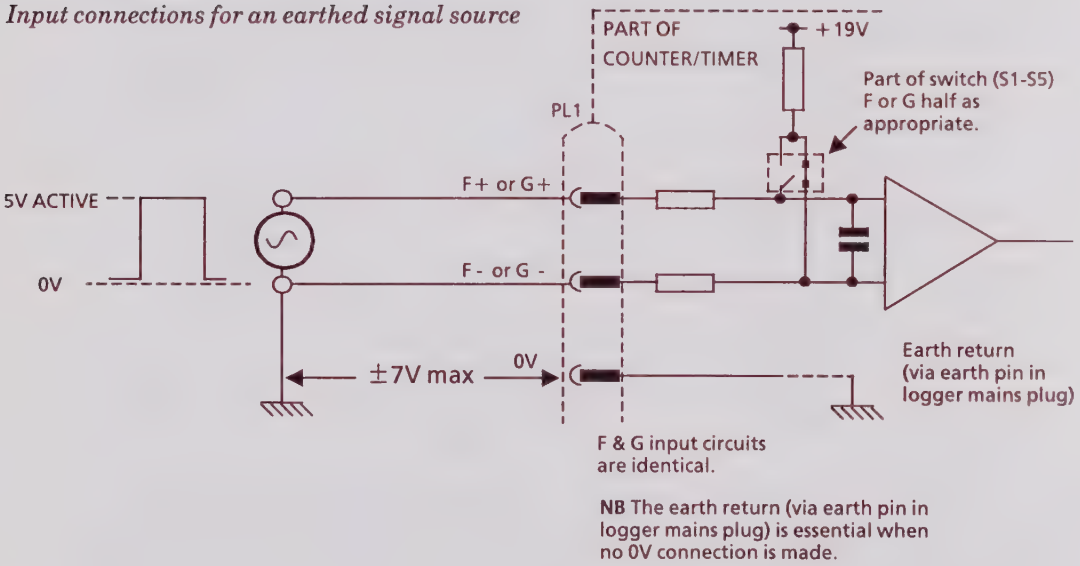


Fig 9.46 *Differential inputs - active Lo.*

Input connections for a floating signal source



Input connections for an earthed signal source



S1 to S5 Settings (for floating or earthed signal source)

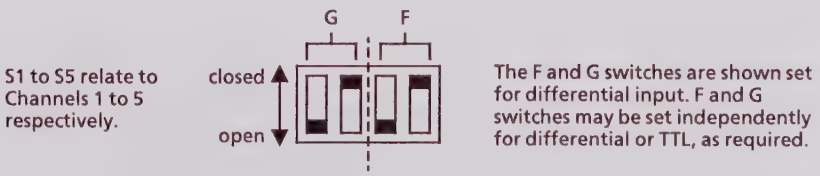
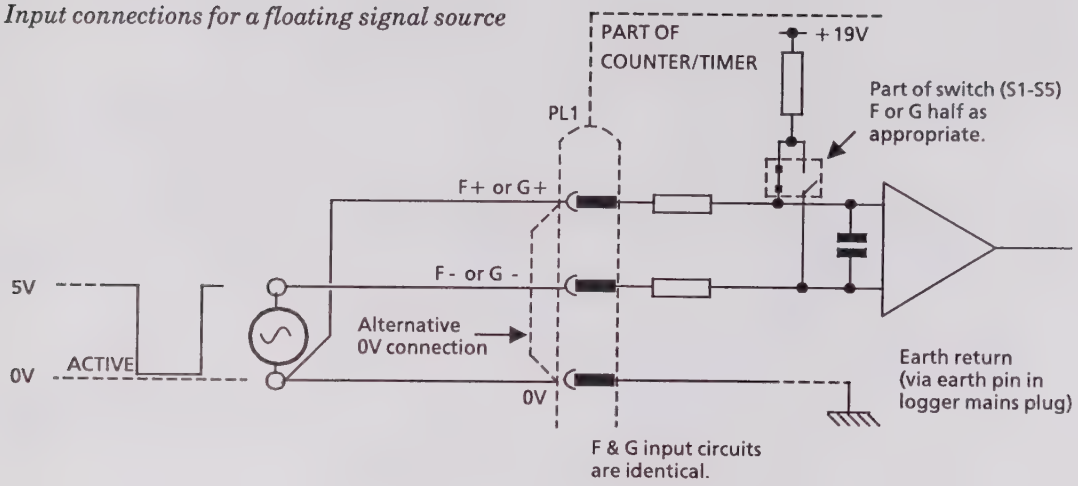
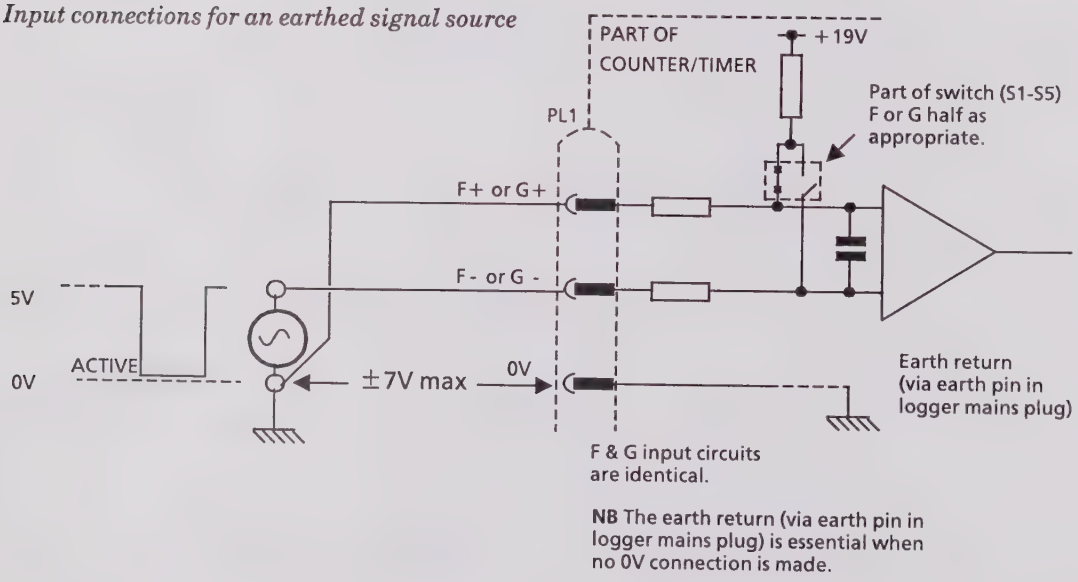


Fig 9.47 *TTL inputs - active Hi.*

Input connections for a floating signal source

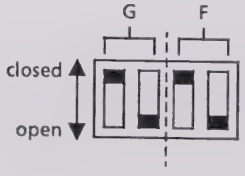


Input connections for an earthed signal source



NB The earth return (via earth pin in logger mains plug) is essential when no 0V connection is made.

S1 to S5 Settings (for floating or earthed signal source)



S1 to S5 relate to Channels 1 to 5 respectively.

The F and G switches are shown set for differential input. F and G switches may be set independently for differential or TTL, as required.

Fig 9.48 TTL inputs - active Lo.

7 ANALOG OUTPUT MODULE

7.1 ANALOG OUTPUT FUNCTIONS

The function of the Analog Output Module (SI 35301E) is to provide five output channels for driving external devices such as plotters and chart recorders. Each channel outputs a scaled voltage or current proportional to the measured result from the corresponding input channel.

Analog outputs are set up with the Scale and Value facilities within the Channel Definition. The outputs can also be controlled via one of the SI 3535 external command interfaces: this allows a computer, which may be processing results derived from measurements, to produce a change of state in an analog output.

The preferred location for an Analog Output Module is slot number 5 of the SI 3535 backplane.

NOTE: The combined total of Analog Output and Counter Timer Modules must not exceed five per SI 3535 unit.

7.2 SETTING-UP PROCEDURE

Initially, each output must be set up as required, using Channel Definition for the output channel. For normal use select Scale, or for setting-up or test purposes only, select Value, as follows:

SCALE: Enter two values which represent measurements obtained from the nominated input channel:

(a) The input measurement which will give a minimum (0%) output.

(b) The input measurement which will give a maximum (100%) output.

This sets up the scaling and offset for the output channel.

VALUE: Enter the set value (percentage) of output required.

7.2.1 Scale Facility

The Scale 0% and 100% values can be set as required for any given user application. For example, to produce a direct scaling factor with no offset, set the 0% value to zero input (e.g. zero microstrain, from a strain gage input channel) and the 100% value to the maximum level expected (e.g. 250 microstrain). To produce a negative scaling factor make the 100% level lower than the 0% value.

Scaling in which the maximum (100%) and minimum (0%) measurements are defined, permits maximum resolution of results within a specific range. As an example, assume that an analogue output channel is driving a plotter to produce a plot of temperature, as measured by a thermocouple on the associated input channel. The temperature that is likely to be measured is between 50°C and 85°C. Therefore, the Scale '0%' value is set to 50 (= 50°C) and the '100%' value is set to 85 (= 85°C) to apply a scaling and offset to the output. Fig 9.49 shows the relationship that results between the output voltage or current and the input channel measurement; the output channel always produce a fixed output level, being updated by each input measurement. The complete output range is used to indicate measured temperatures between 50°C and 85°C, thus giving maximum output resolution over the selected input range.

For scaling, check that the number of an output channel is entered in the Channel Definition for the associated input channel, to link the nominated input with the output channel. Thus, whenever that input channel is scanned or monitored, the result obtained causes the output channel to produce a proportional voltage or current output, within the scaling limits (0% and 100%) previously entered. This output level is maintained until it is updated by another measurement, from a scan or by monitoring (Fig 9.50).

Note that the 0% output level, when set to voltage, is maintained from switch-on until the first result becomes available. When the output is set to current an output of 0mA is obtained until the output is set. The output level obtained from a scan or monitor result is maintained until updated by the next scan or monitor measurement. The output is unaffected by the Halt command or by monitor being switched off. Since monitoring produces repetitive measurements, each measurement produces an updated output.

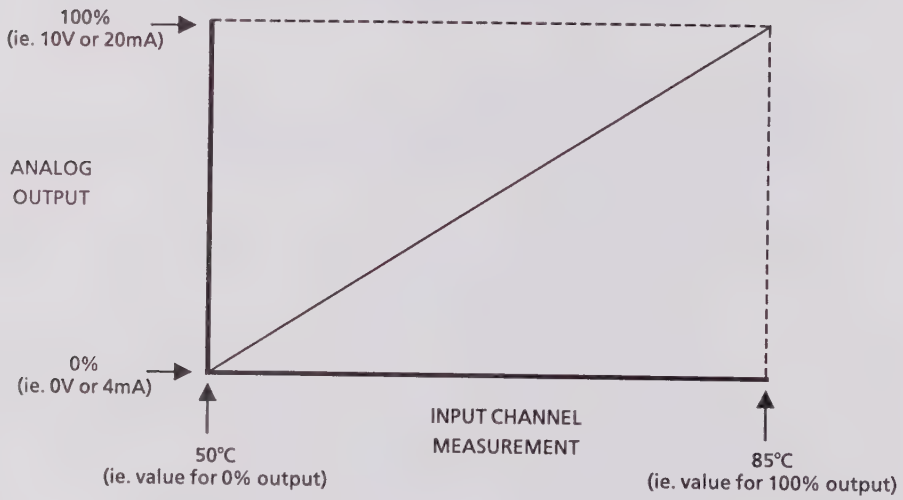


Fig 9.49 *Example of Scaling Facility.*

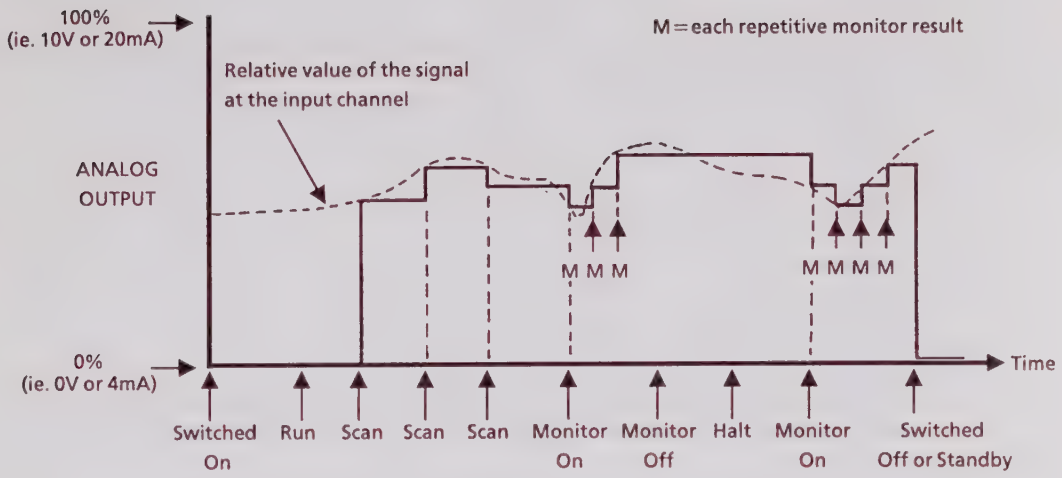


Fig 9.50 *Typical Analog Output.*

7.2.2 Value Facility

The Value facility can be used manually to change the analog output at any time. The scan or monitor measurement of the input channel, used to control an output, is given after engineering units, or a conversion has been performed.

The actual value can be obtained by selecting the Channel Definition for the output, and entering Value. The present output level is indicated, irrespective of whether it was set using Value or by a measurement of the associated input channel using the Scale facility. The value of the output may also be inspected at any time by monitoring the output channel, using the Monitor facility.

7.3 CONNECTION PROCEDURE

To use the analog output module in conjunction with external recording devices, proceed as follows:

1. Using 25-way sub-miniature D-type connectors (which mate with PL1 and PL2) make up the connections for the output devices. For Current output channels, connect as shown in Fig 9.52 and for Voltage output channels, connect as shown in Fig 9.53. Details of the PL1/PL2 pin connections are given in Table 9.7.

2. With the SI 3535 switched off, remove the Analog Output Module from the backplane.

3. For output channels 1 to 5 set the associated switches, S101 to S501, to either CURRENT or VOLTAGE.

4. Set S1 (CH1 and CH5) to correspond with the CURRENT/VOLTAGE settings of S101 to S501.

5. For current outputs only, connect/disconnect links SP106 to SP506 as required (Section 7.4).

   NOTE: Split Pads (SP) 106 to 506 relate to channels 1 to 5 respectively.

6. Refit the module in the backplane, and fit the sub-miniature D-type connectors to PL1 and PL2.

7. With the SI 3535 switched on, select Channel Definition and set up the Analog Output channels as required.

   NOTE: The output channel numbers are as follows:

   1-5, if fitted in Slot 4
   21-25, if fitted in Slot 5

   ↓

   181-185, if fitted in Slot 13

8. Ensure that the Channel Definition for each associated input channel contains the appropriate output channel number, i.e. under OUTPUT, enter analog output channel.

   NOTE: On initially requesting OUTPUT, the Display will request the O/P Channel numbers for the digital Alarm outputs. By pressing ENTER, the Display changes to request:

   "Enter analog output channel"

9. Incorporate the associated input channel(s) into one or more Tasks as required, using Task Definition.

   NOTE: It is not possible to apply either Event inputs or Bit Status inputs to an Analog Output channel.

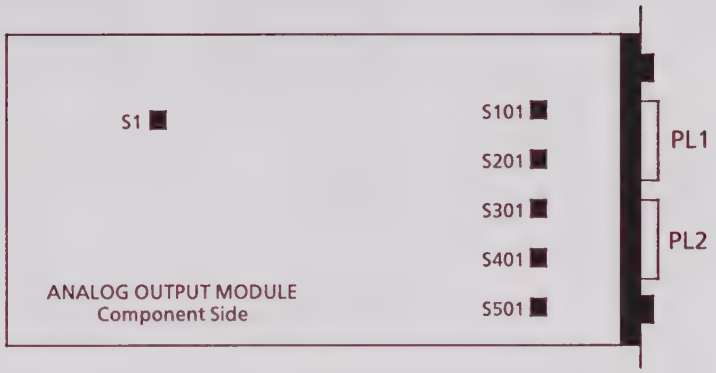


Fig 9.51 *Location of Switches S101 to S501 and S1 on analog output module.*

Table 9.7 Analog Output Channel Connections

PL1 : Contains Channels 1-3

PL1 Pin No.	Signal		
	CH1	CH2	CH3
1	I+		
2	V+		
3	V+		
4			
5		I+	
6		V+	
7		V+	
8			
9			
10			I+
11			V+
12			V+
13			
14	I-		
15	V-		
16	V-		
17			
18		I-	
19		V-	
20		V-	
21			
22			
23			I-
24			V-
25			V-

PL2 : Contains Channels 4 and 5

PL2 Pin No.	Signal		
	CH4	CH5	0V
1	I+		
2	V+		
3	V+		
4			
5			
6			
7			0V
8			
9			
10		I+	
11		V+	
12		V+	
13			
14	I-		
15	V-		
16	V-		
17			
18			
19			0V
20			0V
21			
22			
23		I-	
24		V-	
25		V-	

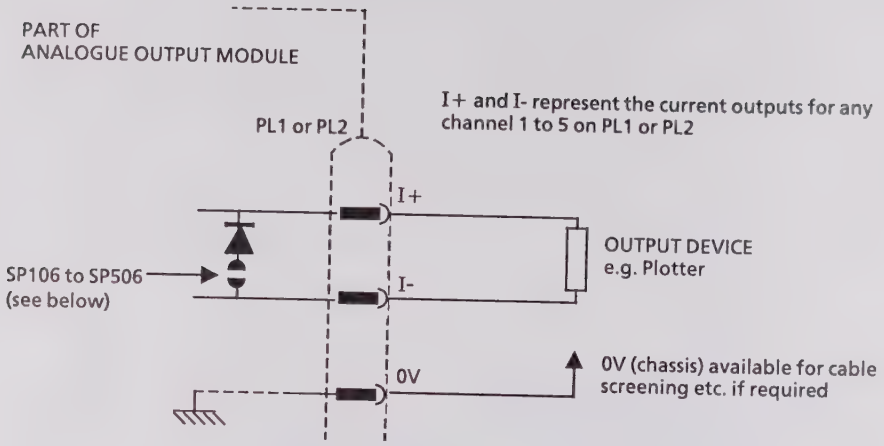


Fig 9.52 *Analog output, current connections.*

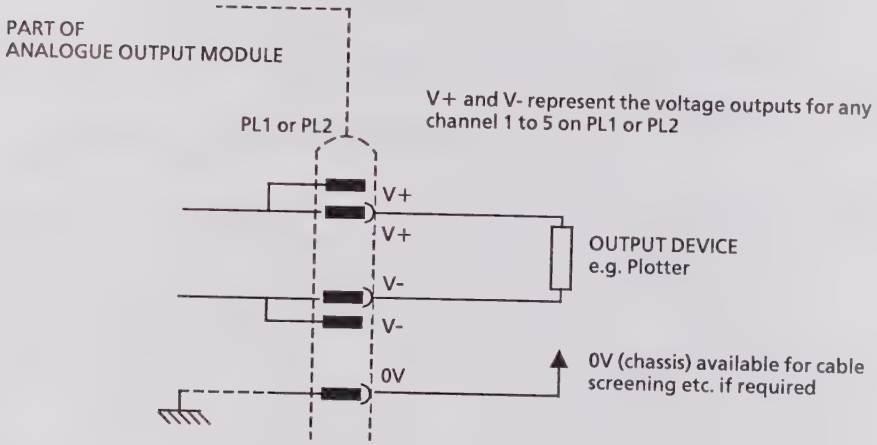


Fig 9.53 *Analog output, voltage connections.*

7.4 CURRENT OUTPUTS

Details of the current range, and of the switch settings for the current output channels, are as follows:

Output Current Range: 4 mA to 20 mA (4 mA = 0%, 20 mA = 100%)

Output Voltage Compliance: 10V, i.e. voltage across the output device must not be allowed to exceed 10V, for correct current output.

SP106 to SP506: Split pads SP106 to 506 relate to channels 1 to 5 respectively. The Analogue Output Module is supplied with all links connected. Each channel thus has the catching diode connected across the current outputs, giving protection against back emfs when using inductive loads. Any link may be disconnected if required. Links SP106 to 506 are located on the pcb, close to S101 to 501 respectively.

7.5 VOLTAGE OUTPUTS

The output connections for voltage, to a typical output device, e.g. plotter, are shown in Fig 9.53. Details of the voltage output channels are as follows:

Output Voltage Range:	0V to 10V (0V = 0%, 10V = 100%)
Output Current:	0mA to 20mA

Chapter 10
Transient Capture

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1 INTRODUCTION

The SI 35351F Transient Capture Module provides a four-channel transient capture capability. On each channel the input signal may be sampled at rates of up to 50,000 samples/second, and an extremely flexible triggering mechanism allows the capture of transients for virtually any trigger condition.

One million captured samples can be stored on each module. The number of samples to be stored for each transient is defined by the user and this allows the memory available for storage to be apportioned as required: if necessary, the total storage capacity may be used by a single channel.

1.1 SIMPLIFIED SCHEMATIC

A simplified schematic of the SI 35351F is shown in Fig 10.1. Referring to this, a pair of dual-input ADCs continuously measure two pairs of inputs (Channels 1 and 2 and Channels 3 and 4). Once the SI 35351F is armed, the ADC outputs are circulated in memory until captured in accordance with user-defined trigger conditions.

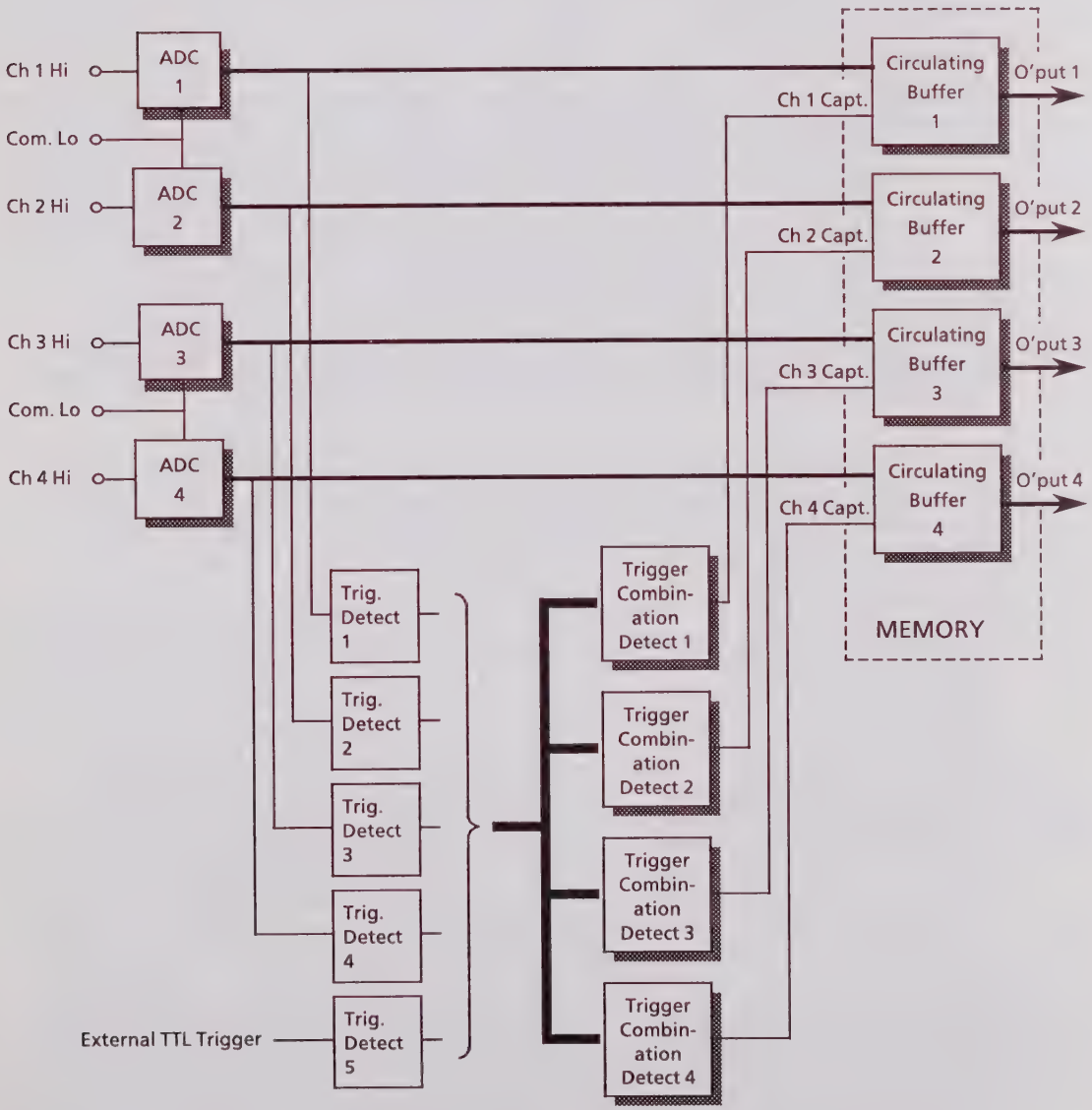

Fig 10.1 *Simplified schematic of Transient Capture Module SI 35351F.*

1.2 ARMING AND TRIGGERING

In capturing a transient there are two main control aspects: arming and triggering.

Arming applies to an entire transient capture module: when a module is armed it prepares to capture transient data, when it is disarmed it doesn't. Depending on its operating mode, a module may be armed by remote command or by the clock, the timer, or a task. The measurement modes of the 35351F are described in Section 1.4 below.

Triggering is set up for each channel, together with the other parameters which relate to transient capture. A general introduction to transient capture, with the emphasis on triggering, is given in Section 1.3 below.

1.3 TRANSIENT CAPTURE

Once a module is armed, the following actions occur concurrently on each channel:

- The input signal is continuously measured by an ADC and the amplitude samples thus obtained are circulated in a memory buffer. The ADC input range can be selected to obtain the best possible amplitude resolution and the sample rate can be selected to reduce the likelihood of aliasing errors. The size of the memory buffer is determined by the number of samples (results) that the user wishes to capture.

- A Trigger Detect circuit (see Fig 10.1) compares the input signal with a user-defined *Detection Type* specification. A trigger may thus be detected when the input signal reflects a particular phenomenon of interest. A detected trigger is not used directly, however, but is applied via a Trigger Combination Detect circuit, in accordance with a user-defined *data capture* condition (entered under "trigger condition" in the menu). Thus, data can be captured with a single trigger or with a combination of triggers from two or more channels.

Once the specified trigger, or combination of triggers, occurs, the content of the relevant circulating buffer is "frozen" (i.e. captured) until output in accordance with the user's instructions.

Transient capture triggering may, at first sight, appear rather daunting. However, with the flexible triggering facilities provided, transient capture can be as simple or as complex as you like and, once you understand the basic principles, it is reasonably easy to set up and apply.

For example, you can set a channel to self-trigger simply by specifying its own trigger detect output as its capture condition, e.g. "1" for Channel 1, "2" for Channel 2, etc. Again, it is possible to set up one or more channels to trigger on the same single trigger, e.g. data on Channels 1 through 4 may be captured concurrently simply by specifying the same trigger detect, e.g. "5" as the capture condition for all channels.

Combination triggering makes the capture of a transient dependent on more than one phenomenon. For example, by specifying the capture condition for Channel 1 as "(1AND2)", it can be arranged for a transient to be captured on Channel 1 only when a trigger is detected on Channel 1 *and* on Channel 2. Another example might be to capture a transient on Channel 2 when a trigger is detected on Channel 2 *or* the External TTL trigger input: for this you would specify the capture condition for Channel 2 as "(2)OR(5)". (The external trigger is identified as Trigger 5.)

Further complexity may be added by inverting the sense of a trigger at the input to the Combination Detect circuit. This allows a transient to be captured only when a trigger is *not* detected, i.e. when a certain phenomenon is *not* present in the system being monitored. An example of this could be to capture a transient on Channel 3 when a trigger *is* detected on Channel 3, but *not* on Channel 4: for this you would specify the capture condition for Channel 3 as "(3ANDNOT(4))". (The syntax used in this

statement, and the other capture condition statements above, is explained in Section 3.5 of this chapter.)

The final aspect of combination triggering is to specify whether or not one (or more) of the triggers used is to be latched. With *un*latched triggers all the related input phenomena must occur at the same time for a transient to be captured. This is because the output of a Trigger Detect circuit is negated immediately the phenomenon producing it has disappeared. However, when a trigger detect output is latched it remains asserted. This allows a previously occuring phenomenon to be "remembered" and combined with a presently occuring phenomenon to capture a transient.

Pre- or post triggering is available for each channel to allow optimum placing of the trigger point, in relation to the transient to be captured. Pre-triggering is selectable between 0% and 100%, while post triggering is selectable between 0% and a minimum of 1600% (for one million stored results from a single channel).

All of the above aspects of transient capture are fully described in Section 3 of this chapter, together with other aspects such as the output of captured data and the action to be taken at the beginning, and on the completion of, a transient capture.

1.4 MEASUREMENT MODES

Transient channels may be scanned by a task, or monitored, in the same way as all other types of input channels. This yields the latest measured value. There are, however, two modes of the SI 35351F which are peculiar to transient capture: these are the *standalone* mode and the *interactive* mode, both of which can yield up to one million results (samples).

The standalone mode is intended mainly for unattended operation; for example, in the capture of occasional transients over a long period. Measurements are made and the resulting data output automatically: the module may then be rearmed immediately, or rearmed under the control of the clock, the timer, a task, or an EXternal ARm command. The standalone mode requires the logger to be in the RUN state.

The interactive mode allows you to select the results to be output. Once the results have been captured the SI 35351F outputs an alert message and awaits your decision. An EXport command causes the module to output the result and an ARm command rearms the module ready for the next transient. If the results are not wanted, the module may be rearmed without exporting them, in which case the unwanted results are deleted. It is not necessary for the logger to be in the RUN state to operate the interactive mode.

Further details of the measurement modes are given in Sections 4 and 5 of this chapter.

1.5 DRIFT CORRECTION

The SI 35351F module is able to compensate for offset and gain drift in its input amplifiers by comparing the measured values of on-module voltage references with the known precision values. This facility may be set to run automatically or, alternatively, may be actioned by the user when convenient. (See Section 3.11 of this chapter for further details.)

NOTE: Although two Lo input connectors are provided for each input channel pair they are connected together internally and should not have different voltages applied.

2 INSTALLATION

A transient capture module occupies two slots in the logger mainframe and can be fitted in any of the positions shown in Fig 10.2. A maximum of four transient capture modules can be fitted, giving a total of 16 transient capture channels. The channel numbering is shown in the diagram. (See Section 3.1 for explanation.) Transient capture modules may be mixed with all other SI 3535 logger modules.

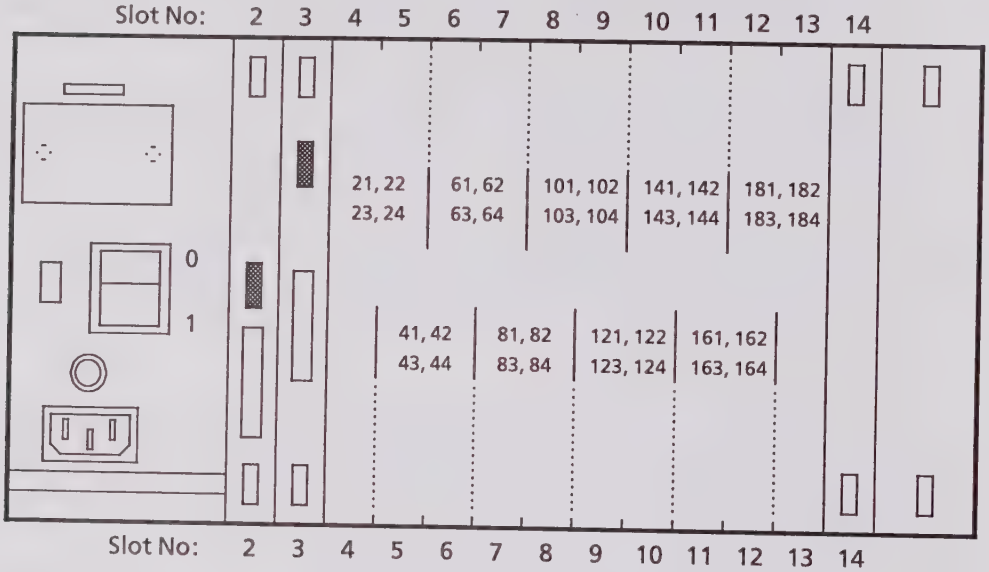

Fig 10.2 *Channel numbering of the transient capture modules.*

Fig 10.3 shows the end panel layout of the transient capture module and the input connector pin functions.

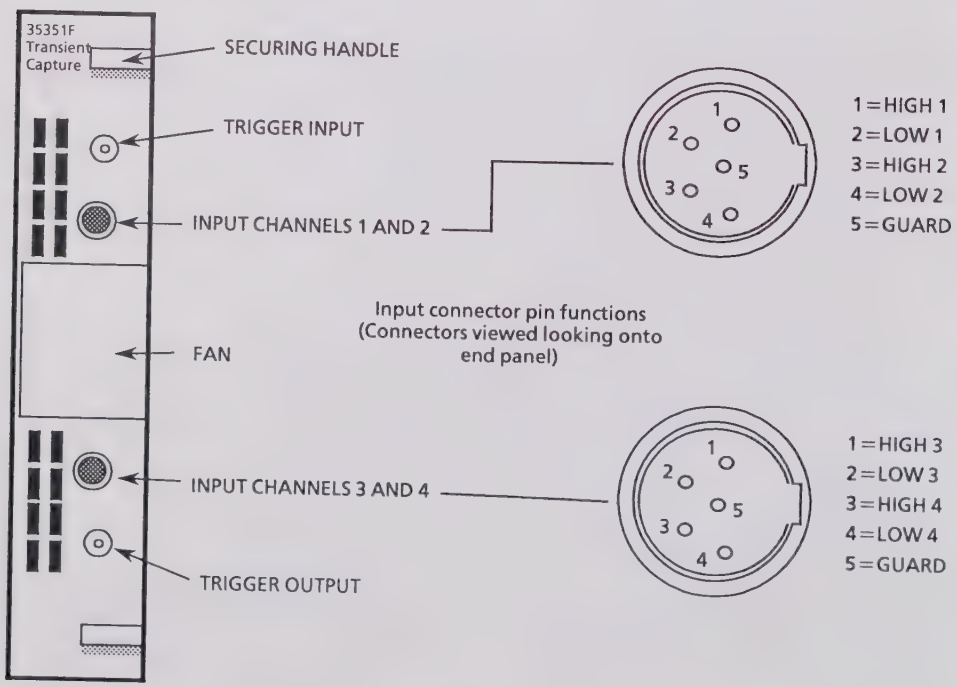

Fig 10.3 *End panel layout of the transient capture module.*

3 CHANNEL DEFINITION

All setups described in this section are applicable to transient capture *channels*. Each channel may have its own definition; or several channels may have the same definition. In the latter case the channels may be distributed throughout several transient capture modules, each module operating in either the standalone or interactive mode. The program menu for channel definition is shown in Fig 10.14 at the end of this chapter.

(Note that operating *modes* are specified for transient capture *modules* and that all channels within a module operate in the same mode. For details of mode selection see Section 4 in this chapter.)

3.1 TRANSIENT CHANNEL NUMBERS

Enter the number(s) of the transient capture channel(s) you wish to set up. Where several channels are to be set up these may be contained in several modules, regardless of the module operating modes.

The channel numbers that you use are shown in Fig 10.2. On each transient capture module the four input channels are identified, on the end panel, as Channels 1, 2, 3, and 4: these are the digits which appear at the end of the actual channel numbers, e.g. **21**, **22**, **23**, **24** ; **41**, **42**, **43**, **44** ; etc. For simplicity, the input channels are generally identified as Channels 1 to 4 throughout this chapter.

3.2 INPUT RANGE

The input range is selectable from one of four fixed ranges. Autoranging is not made available, since this could result in lost data. The four fixed ranges are:

- 10mV
- 100mV
- 1V
- 10V

3.3 SAMPLING RATE

The input sampling rate may be selected from the values shown in Table 10.1.

Table 10.1 Sampling Rate v. Max. I/P Freq.

Sampling Rate (samples/sec)	Frequency Band which may lead to Aliasing Problems
5	2.5Hz—21kHz
50	25Hz—21kHz
500	250Hz—21kHz
5000	2.5kHz—21kHz
10000	5kHz—21kHz
25000	12.5kHz—21kHz
50000	No problems*

*Transient capture module has a built-in anti-alias filter (≈ 21kHz)

Note the alias frequency band given against each rate: alias frequency errors will appear in the measurement results if frequencies within the given band are contained in the input signal. Aliasing can be avoided by using a sufficiently high sampling rate. The effect of signal aliasing is demonstrated in Fig 10.4.

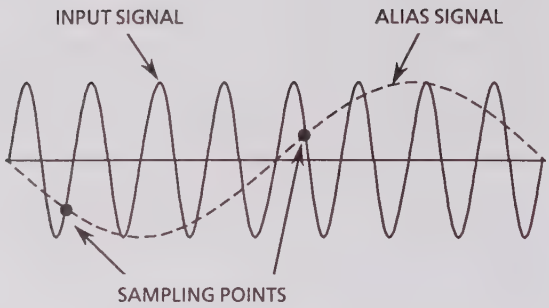

Fig 10.4 *Example of "alias" measurement.*

The 35351F provides excellent anti-alias filtering for the maximum sample rate of 50,000 samples/sec. Note, however, that the anti-alias filter does not cut off instantly, but has the "roll-off" characteristic shown in Fig 10.5. Therefore errors may still be introduced above 25kHz, although at a reduced level.

Similarly, with sampling rates between 5 samples/sec and 25,000 samples/sec inclusive, errors may still be introduced at a reduced level above 21kHz.

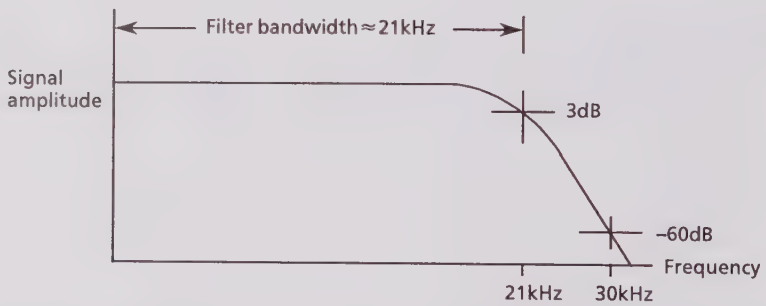

Fig 10.5 *Characteristic of built-in anti-alias filter.*

3.4 TRIGGER DETECTION

To enable a transient to be captured, the input signal is applied to a Trigger Detect circuit where it is compared with user-defined *detection type* parameters. These parameters are set to reflect a significant and unambiguous state by which the transient can be identified. When the transient type parameters are satisfied, the Trigger Detect circuit outputs a channel-related trigger signal. This can be used to identify the point of capture, for the buffered signal data in memory (see Section 3.5.5).

A channel-related trigger signal is not used directly, however, but is applied via a Trigger Combination Detect circuit. This allows the trigger to act in conjunction, or alternation, with other channel-related triggers to produce a capture trigger. (For an introduction to combination triggering, see Section 1.3.) Trigger combination setups are described in Section 3.5.

Under "Trigger Count" (see Fig 10.15 at the end of the chapter) you can specify the number of samples which must satisfy the detection type parameters before a capture trigger is output: this gives a degree of noise rejection. Samples which meet the trigger conditions increment the count, whilst samples which don't meet the conditions decrement the count towards zero. The maximum count which may be specified is 65535.

The types of trigger detection that may be employed are:

- Positive threshold.
- Negative threshold.
- Positive threshold, with hysteresis.
- Negative threshold, with hysteresis.
- In window.
- Out of window.

The way in which each of these operates is described in Sections 3.4.1 through 3.4.3 below.

3.4.1 Threshold Trigger

A threshold trigger may act in a positive or negative direction. In the case of a positive threshold a trigger is detected when the accrued count of above-threshold samples equals the specified trigger count. For a negative threshold the trigger is detected when the accrued count of *below*-threshold samples equals the specified trigger count.

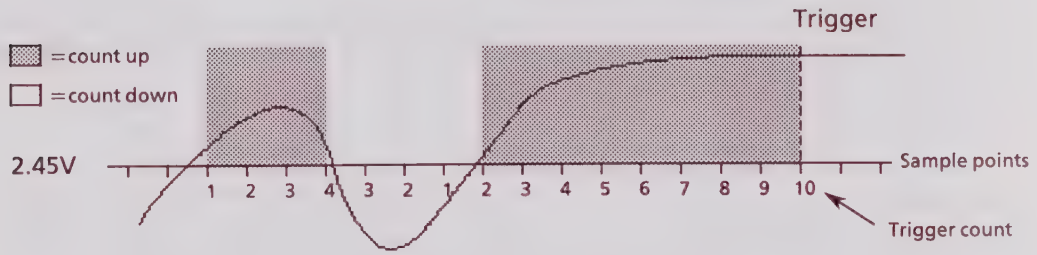

Fig 10.6 *Example of positive threshold trigger.*

Fig 10.6 shows an example of a positive threshold trigger with a specified trigger count of 10.

3.4.2 Threshold Trigger with Hysteresis

To restrict threshold triggering to definite signal excursions a hysteresis threshold may be specified. In the example shown in Fig 10.7 a positive threshold trigger is not detected until the signal level has first fallen below the hysteresis threshold (e.g. 3.75V) and then risen above the positive threshold (e.g. 4.75V) for an accrued sample count equal to the specified trigger count (e.g. 10).

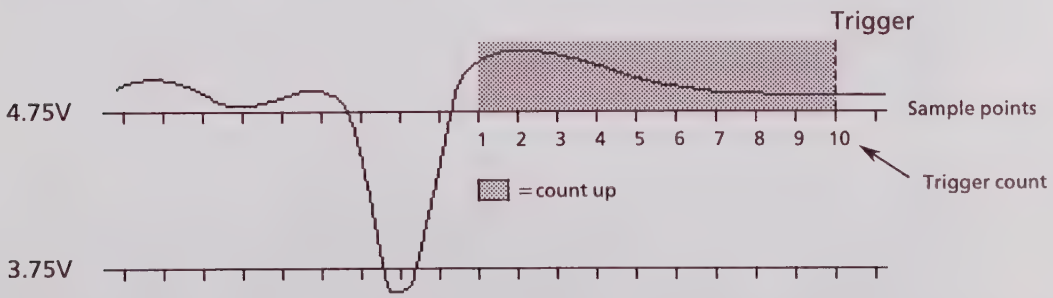

Fig 10.7 *Example of positive threshold trigger with hysteresis.*

3.4.3 Window Trigger

A window trigger is detected when the accrued count of in-window (or out-of window) samples equals the specified trigger count.

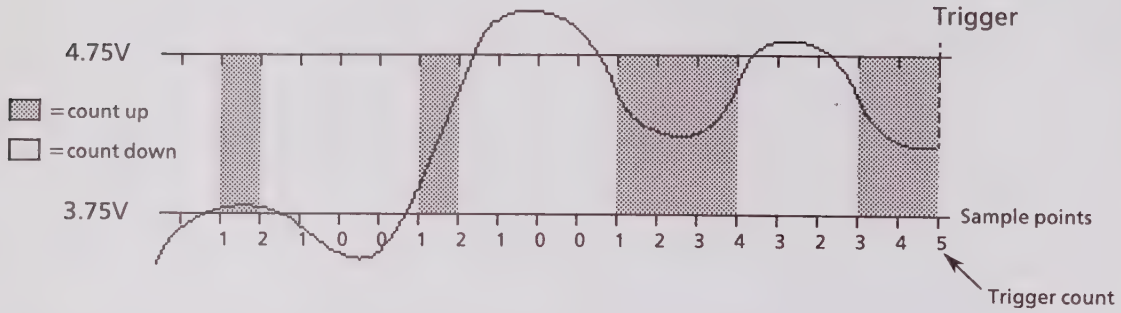

Fig 10.8 *Example of in-window trigger.*

Fig 10.8 shows an example of an in-window trigger. The window is defined by an upper and a lower threshold (e.g. 4.75V and 3.75V) and the specified sample count is 5.

NOTE: To ensure that a hardware trigger is detected the external trigger level must coincide with a sample point, e.g.

3.4.4 Trigger Latching

The output of a Trigger Detect circuit may be set for trigger condition latched, or unlatched, as required.

With unlatched operation ("latched trigger condition Off") the trigger conditions must be present for Trigger Detect to remain asserted. Also, for AND trigger combinations (see Section 3.5), all unlatched triggers must be present before a transient is captured. This allows a transient to be captured only when two or more phenomena occur together.

With latched operation ("latched trigger condition On") Trigger Detect remains asserted after the phenomenon which produced it has disappeared. This allows the occurrence of a phenomenon to be "remembered" and provides for a situation where related phenomena do not necessarily occur at the same time. Thus, a *latched* trigger can be used to arm an AND combination in preparation for an *un*latched trigger.

3.5 TRIGGER COMBINATION

A simplified schematic of the logic available for trigger combination detection is shown in Fig 10.9. The logic is contained in a programmable array and selected parts of this are assembled in accordance with the user-defined *capture condition*. In normal practice, the logic actually used is relatively simple. (The concept of combination triggers is introduced in Section 1.3 of this chapter.)

In the simplest case, i.e.where single-trigger transient capturing is required, the logic array is able to act as a direct link. For example, if Channel 1 is to be self-triggered the capture condition is specified simply as "1": this sets up the internal logic levels of the logic array so that its output acts according to the Trigger 1 input alone. Other logic elements and inputs come into play as more complex capture conditions are specified.

3.5.1 Specifying the Trigger Condition

From Fig 10.9 it can be seen that a combination trigger decode may consist of up to three AND functions ORed together. Further, each AND function can combine up to five trigger inputs, inverted or non-inverted.

The syntax used in specifying a capture condition is illustrated in the following examples. These demonstrate the use of brackets —brackets should always enclose the following items:

- The identities of triggers to be ORed.

  For example: (1)OR(5) —*this captures data when Trigger 1* OR *Trigger 5 is detected.*

- Expressions representing ANDed triggers.

  For example: (1AND2AND5)OR(3AND4) —*this captures data when Triggers 1* AND *2* AND *5 are detected,* OR *Triggers 3* AND *4 are detected.*

- The identity of any trigger whose sense is to be inverted.

  For example: (2ANDNOT(3)) —*this captures data when Trigger 2 is detected* AND *Trigger 3 is* NOT *detected.*

Spaces are not essential, but may be added for clarity if you wish.

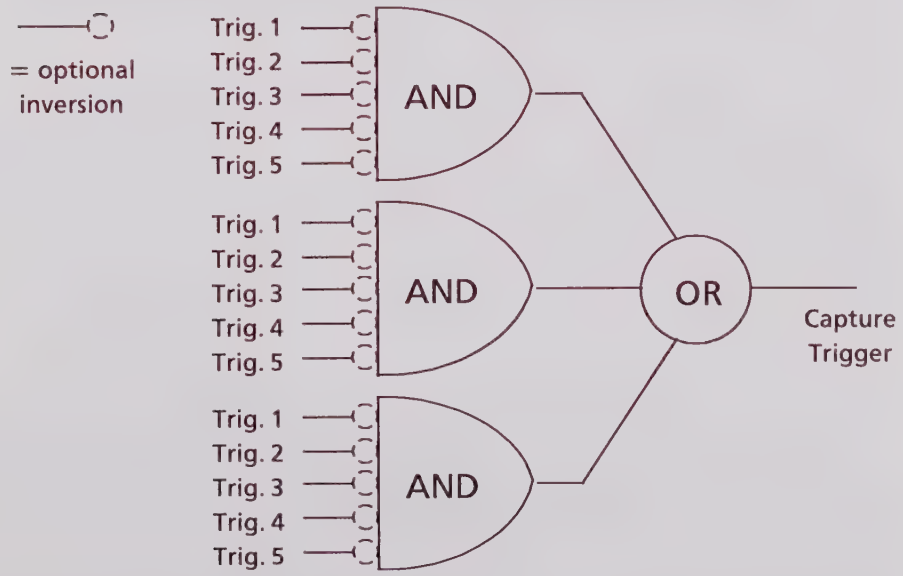

Fig 10.9 *Logic diagram of the combination trigger decoding circuit.*

3.6 RESULT CAPTURE

Results are captured, i.e. frozen in memory, when a capture trigger occurs. The various aspects of result capture in relation to the trigger are described below.

3.6.1 Number of Results Stored

The maximum number of results that may be stored on a single transient capture module is one million. All of this storage may all be allocated to a single channel or it may be shared between several channels.

If a capture is defined to collect pre-trigger data and the trigger occurs immediately on ARMing, then fewer results than requested will be captured.

The number of results which have been captured can be viewed using the buffer status under the control menu.

3.6.2 Placing the Captured Transient in Relation to the Trigger

By specifying the number of results between the trigger and the first result to be stored the stored transient can be placed anywhere in relation to the trigger. This allows a transient to trigger at any convenient point, whilst ensuring that all significant results are captured.

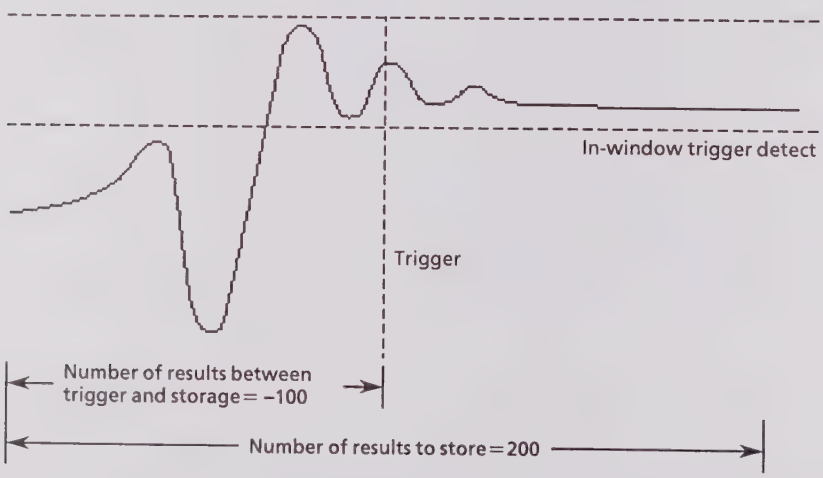

Fig 10.10 *Example of transient capture with center trigger.*

The example in Fig 10.10 shows a captured transient that is positioned centrally about the trigger. In this particular case the number of results stored is 200. By specifying the number of results between trigger and storage as –100 the transient capture starts 100 results before the trigger, i.e. the captured transient is center triggered.

The above example demonstrates a pre-trigger of 50%. The maximum pre-trigger is 100%, which in this case would be –200 results.

> **NOTE:** If a transient capture is set to collect pre-trigger data, and the trigger occurs immediately on arming, then less results will be captured than requested. The number of results that *have* been captured can be viewed using the Buffer Status command, which appears in the CONTROL menu.

Post-triggering can also be used, where the transient capture starts after the trigger. The maximum post trigger count is 16,000,000, which, for a result count of one million, is 1600%.

3.6.3 Trigger Time Uncertainty

On odd numbered channels the trigger time has an uncertainty which depends on the input sampling rate. On all sampling rates, except 50,000 samples per second, trigger detect may be delayed by one sample period. In the transient capture printout this would result in the "=" sign appearing against the sample following the trigger sample.

Therefore, to obtain the most accurate trigger times, the even numbered channels should be used for trigger detection. For example, a critical result on Channel 1 could be captured either by a single trigger on Channel 2 (D2) or by the combined triggers on Channels 2 and 4 (D2 AND D4).

3.7 ACTIONS ON CAPTURE TRIGGER AND MEASURE COMPLETE

One of four actions can be taken at the following points:

(a) when the capture trigger occurs, and

(b) when the last result is captured, i.e. on "measure complete".

In each case, the choice of actions offered is:

- Arm another transient capture module. (Identify the module by the number of its first channel.)
- Enable a task. (Specify the task number.)
- Abort a task. (Specify the task number.)
- Output the hardware trigger.

3.7.1 Hardware Trigger Output

From Fig 10.15 (at the end of this chapter) it can be seen that the hardware trigger output can be set up as follows:

(a) "at trig" The trigger output is asserted at the capture point and cleared on measurement complete,

(b) "at cmpl" The trigger output is asserted on measurement complete and cleared almost immediately (a few microseconds) afterwards.

3.8 OUTPUT

In the "Transient" PROGRAM menu the output format and device are specified for the Stand Alone mode only. The output format and device for the Interactive mode are specified in the "Transient" CONTROL menu. In either case, however, the same selection of output formats and output devices is applicable, as shown in Table 10.2.

Table 10.2 Output Format Availability

OUTPUT DEVICE	FORMATS AVAILABLE			
	Full	Coded	Binary	Raw
Display	•			
Printer	•			
Disk*	•	•		
GPIB	•	•	•	•
RS232	•	•	•	•
RS422a,b	•	•		

*Available in standalone mode only. •=format available.

Due to the fact that a captured transient consists of many results, the output formats available for transient capture data are somewhat different to the output formats available for scan results. The characteristics of each transient capture format are summarized below, whilst full details are given in the SI 3535 Reference Manual.

NOTE: Should the results obtained be consistently in the region of zero (e.g. 10^{-18}) it is an indication that calibration has been lost.

3.8.1 Full Format

Data in the full format can be read by the operator and is used in place of the full and compact formats reserved for scan results. Data is output in 20-character lines and consists of six header lines, the results and three footer lines, as shown in the following example of results captured on the 10V range:

```
T T TRANSIENT TEST 1      -----  Transient text label
T D 021     22-09-92      -----  Transient start date
T S   14:30:35.51254      -----  Transient start time
T O-0000:00:00.80000      -----  Transient trigger delay time (from first sample to trigger sample)
T I  000:00:00.20000      -----  Transient interval time (between successive samples)
T N  15   ----------------       Number of results captured
T 021 1.005    Vdc<
T 021 1.501    Vdc<
T 021 2.006    Vdc<
T 021 2.502    Vdc<
T 021 3.006    Vdc=
T 021 3.501    Vdc>
T 021 4.005    Vdc>
T 021 4.502    Vdc>
T 021 5.007    Vdc>
T 021 5.503    Vdc>
T 021 6.005    Vdc>
T 021 6.504    Vdc>
T 021 7.006    Vdc>
T 021 7.505    Vdc>
T 021 8.006    Vdc>
T H   8.006    Vdc  -------      Transient channel maximum result
T L   1.005    Vdc  -------      Transient channel minimum result
T E 021   ----------------       Transient end of export or Transient export aborted
```

Transient channel results
< indicates pre-trigger result
= indicates trigger result
> indicates post-trigger result

3.8.2 Coded Format

Coded Format is intended primarily for recording data on the logger disk, but data thus recorded may be saved to any other device. Each result in coded format is a binary number encoded into a string of ten printable ASCII characters. Texts are not output in coded form, so the transient text label is not included with the captured results: however, all the numeric information listed above for the full format is included. Coded format takes up minimum disk space and therefore permits the maximum number of results to be recorded. Results recorded in coded format are normally replayed only in the logger.

3.8.3 Binary Format

Binary Format is the most convenient way of exporting data (via the GPIB or the RS 232 or RS 422a,b serial interface) for subsequent processing by computer. (Binary format needs no complex decoding, prior to being used by the computer.)

3.8.4 Raw Data Format

Raw data format is used to export transient results as quickly as possible. In this format the 16-bit unlinearized data from the transient capture ADC is exported, together with a header that tells a computer how to process the data. The data that is output in raw format is summarized below.
Although the data is in different fields, no terminator characters are inserted between the start of the data block and the end.
The content of a block of raw data is as follows:

Introducer character "."
Number of bytes in transfer (4-byte integer).
Transient text label (16 ASCII characters).
Channel number, 21 through 184.
Start date (ASCII).
Start time (ASCII).
Trigger delay time (ASCII).
Interval time (ASCII).
Number of results (4-byte unsigned integer).
Result multiplier (4-byte floating point number: *mmme*).
Result offset (4-byte integer).
:
16-bit results (two bytes; twos complement).
:
End of block, normal or End of block, aborted.

All data in a raw data block is "little endian", i.e. numbers are output with the least significant byte first.

3.9 CONVERSION

A conversion may be applied to the transient capture results. The conversion is specified by a conversion number (1–600) in the transient channel definition. This number points to the actual conversion used, which is defined under "Conversion" in the PROGRAM menu. (See Chapter 5, Section 4.3.)

3.10 TRANSIENT LABEL

The number of the transient label is entered, under "Text", in the transient channel definition. The actual text to appear in the label is entered against the same number, again under "Text", in the PROGRAM menu. (See Chapter 5, Section 4.6.)

3.11 TRANSIENT CHANNEL STATUS

Status messages are available for indicating the progress of transient capture channels. These messages may be selected "On" or "Off" under "Information" in the transient channel definition. When information "On" is selected the logger sends one of the following messages, as appropriate:

I CH *n* TR	Information: Channel *n* is triggered.
I CH *n* MC	Information: Channel n, measurement complete.
I CH *n* AR	Information: Channel *n* is armed.

3.12 DRIFT CORRECT

The SI 35351F module is able to compensate for offset and gain drift in its input amplifiers by comparing the measured values of on-module voltage references with the known precision values. According to your particular transient capture setup, drift correct can either be set to run automatically or can be used under operator control when convenient.

Automatic drift correct may be selected "On" or "Off" under "Drft Crct" in the transient channel definition. With drift correct "On" selected, drift correct occurs when the transient capture module is armed and after the channel has completed its measurement. The correction values obtained when the channel is armed are used to calculate the trigger levels: the values obtained after the channel has completed a measurement are used to linearize the results.

When drift correct is in progress a transient channel is unable to measure its input. Therefore, should a channel be contributing to the complex trigger condition of another channel, it is possible that an automatic drift correct could cause a trigger combination to be missed. In such a case it is better to switch off the automatic drift correct, and command drift correct as an "action to be performed" from the transient CONTROL menu. To avoid gaps in a captured transient, the application of drift correct must be carefully timed.

4 MODE SELECTION

Under local control, the mode of operation of a transient capture module is selected under "Transient, Card", in the PROGRAM menu. (See Fig 10.16.) The two modes selectable are "Interactive" and "Standalone". An "Off" setting is also available for switching transient capture off, whilst retaining the setups in memory. Note that the mode setup applies to all channels on a specific transient capture module.

4.1 MODULE NUMBER(S)

Under "Card" you are prompted to enter the first channel number(s) of the transient capture module(s) to which the mode setup is to apply.

4.2 INTERACTIVE MODE

To select the Interactive mode all you need do is press the "Inter." soft key. The logger then returns to the top level of the Transient menu. The logger need not be in the RUN state for this mode to operate

4.3 STANDALONE MODE

To select the Standalone mode, press the "S/Alone" soft key. You are then prompted to select the arming source and the number of transient capture cycles. (See Sections 3.2.1 and 3.2.2 below.)

4.3.1 Arming Source

A transient capture module may be armed by the Timer, the Clock, or a logging Task. The logger must be in the RUN state for any of these arm sources to act. Note that all channels are armed at the same time, but they may be triggered independently according to their trigger definitions.

Under "Timer" an arm delay is entered. This delay can cover days, hours, minutes and seconds and starts from the time that the logger receives a RUN command.

Under "Clock" the arm start time is entered.

Under "Task" an arm delay is entered. This delay starts from the time that the transient capture module is given an EXternal ARm command.

4.3.2 Number of Cycles

Once armed from one of the sources descibed above, a transient capture module is able to rearm itself automatically after the output of captured transient data. This provides for the capture of a series of related transients. The capture and output of each transient is known as a capture "cycle", and the number of cycles to be executed can be set between 1 and 65535. (A setting of "1" specifies the capture of a single transient.) If an asterisk (*) is entered then the transient capture module continues to look for transients until the logger is set to HALT.

When a transient capture module is re-armed all transient data captured during the previous cycle are deleted and any latched trigger detect states are reset.

5 MEASUREMENT CONTROL

This section describes the operating states, and the commands which must be given to select those states, for the *standalone* and *interactive* transient capture modes.

5.1 STANDALONE MODE

The standalone mode is intended mainly for unattended operation, such as in the capturing and monitoring of occasional transients. The measurement phases of this mode are shown in Fig 10.11. Note that transient captures take place in the logger RUN state.

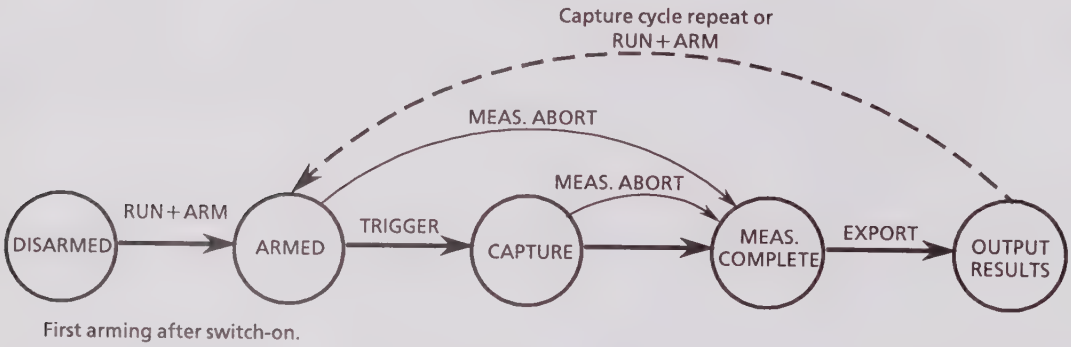

Fig 10.11 *Standalone measurement phases.*

Considering one Transient Capture module, the operating sequence for the standalone mode is as follows:

1. With the logger in the HALT state a RUN command is given. This sets the TC module (and all other standalone TC modules in the logger) to the DISARMED state.

2. The TC module is ARMED from the specified source: Timer, Clock or Task. (See Section 4.3.1 in this chapter.)

3. The results from a specific channel are CAPTUREd in accordance with the capture trigger conditions specified in the channel definition. (See Section 3.5 in this chapter.)

4. When the specified number of results have been captured, a "Measurement complete." message is output (if enabled) and the results are output automatically to the specified output device. (See Sections 3.7 and 3.10 in this chapter.)

5. Depending on the "Number of cycles" count, the TC module either goes automatically to the ARMED state to await a further capture trigger, or remains in the "output completed" state to await rearming. (See Section 4.3 in this chapter.)

At any point in the transient capture sequence the logger can be set to the HALT state. When required, the TC module is again set to the DISARMED state with a RUN command.

A MEASUREMENT ABORT command can be used in the ARMED and CAPTURE phases. This command terminates a transient capture, whilst allowing the results captured so far to be examined: the capture sequence jumps to the MEASUREMENT COMPLETE state and any stored results (e.g. those for pre-trigger) are output. MEASUREMENT ABORT is one of the transient control actions that are accessed from the CONTROL menu. (See Fig 10.16.)

5.2 INTERACTIVE MODE

The interactive mode allows the results of a transient capture to be output selectively. Once the results have been captured the SI 35351F outputs an alert message and awaits an EXport command. This may be given either from the front panel or from a remote controller. Details of the various EXport functions are given below.

An ARm command rearms the module ready for the next transient. If the results are not wanted, the module may be rearmed without exporting them, in which case the unwanted results are deleted.

The measurement phases of the interactive mode are shown in Fig 10.12. Note that it is not necessary for the logger to be in the RUN state for this mode to operate.

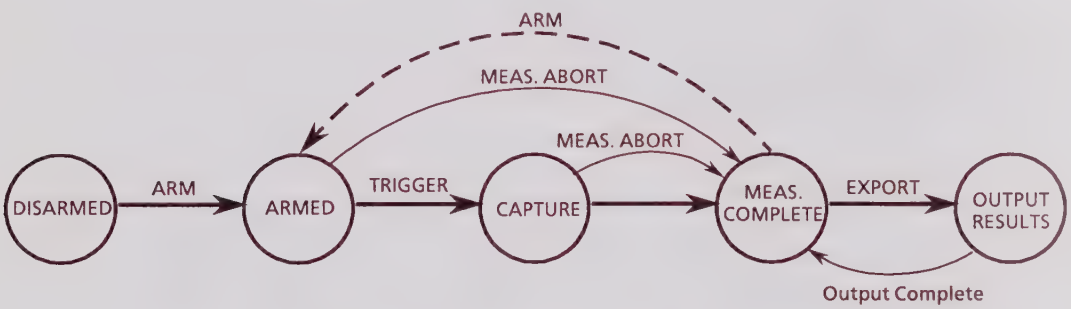

Fig 10.12 *Interactive measurement phases.*

Considering one Transient Capture module, the operating sequence for the interactive mode is as follows:

1. The TC module is ARMed from the "Transient" CONTROL menu or by a remote command.

2. The results from a specific channel are CAPTUREd in accordance with the capture trigger conditions specified in the channel definition. (See Section 3.5 in this chapter.)

3. When a specified number of results have been captured, a "Measurement complete." message is output (if enabled).

4. The EXPORT functions, controlled from the front panel or the remote controller, are used to output the transient capture results. (See Section 5.2.1.) When the specified results have been output the TC module returns automatically to the MEASUREMENT COMPLETE state. A further export may then be commanded, or the module rearmed for another transient capture.

As in the Standalone mode, a MEASUREMENT ABORT command can be used in the ARMED and CAPTURE phases. (See second para. at top of page.)

5.2.1 Export Functions

The transient export functions allow a defined number of transient results to be exported (i.e. output). See Fig 10.13. These results are evenly distributed within a defined portion of the stored transient and hence allow the use of zooming and cursor techniques in determining an area of interest. Once an area of interest has been found the full number of results within that area can be exported.

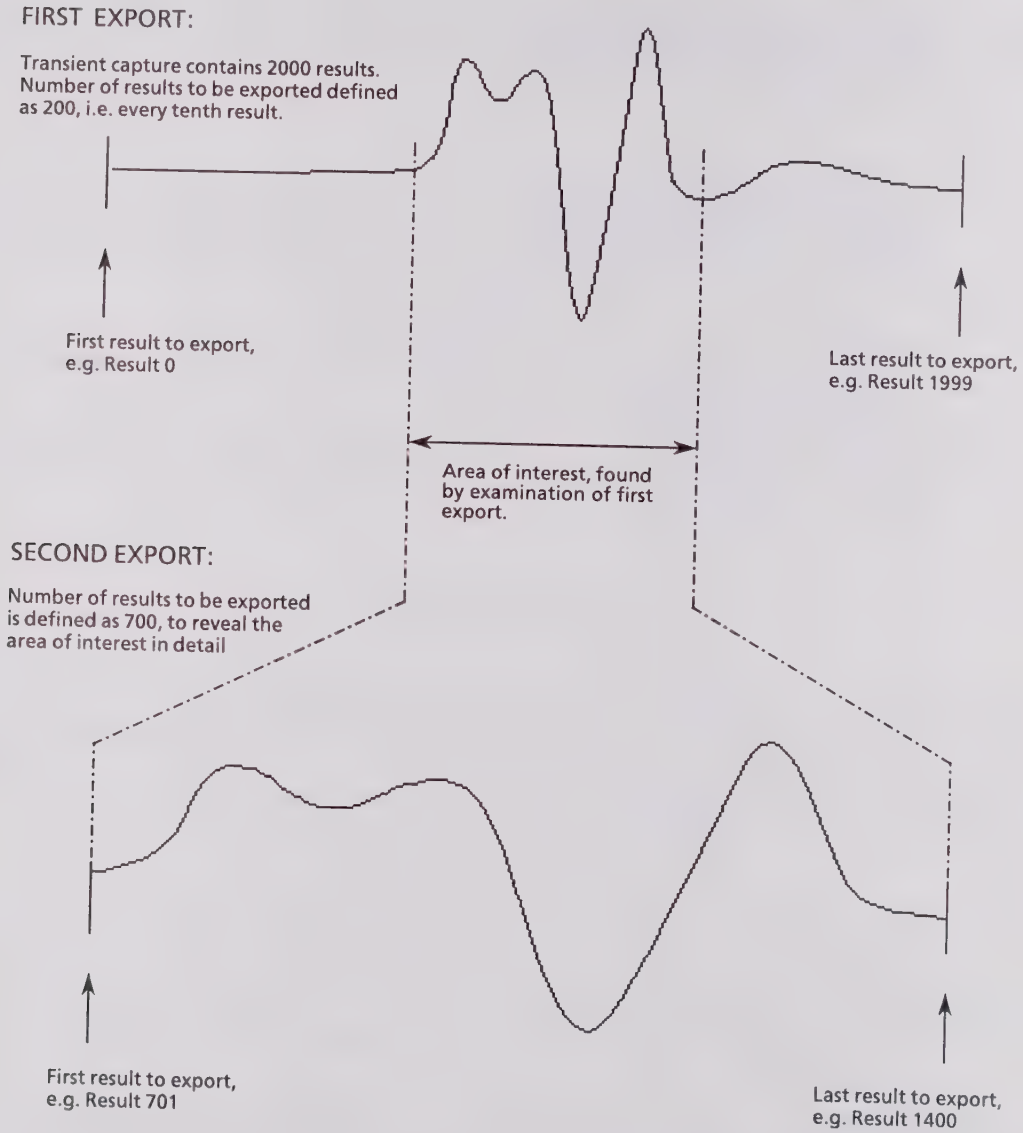
FIRST EXPORT:
Transient capture contains 2000 results. Number of results to be exported defined as 200, i.e. every tenth result.
First result to export, e.g. Result 0
Last result to export, e.g. Result 1999
Area of interest, found by examination of first export.
SECOND EXPORT:
Number of results to be exported is defined as 700, to reveal the area of interest in detail
First result to export, e.g. Result 701
Last result to export, e.g. Result 1400

Fig 10.13 *Definition of results to be exported.*

The portion of the transient that is to be exported may be defined either by the index numbers of the first and last results in that portion or by the times at which the first and last results were measured.

At the time of defining the results to be output you should also define the output format and the output device. You can then use the Start Export function to output the results. Should you change your mind while the results are being output, use the Abort Export command. *See notes overleaf.*

NOTE

Should an export be attempted when no transient data have been captured, or if the results captured are all overload values, then the maximum and minimum values (as output in the export footer lines) are set to their default values, i.e. -1e+18, 1e+18.

CAUTION

Changing the definition of a transient capture channel between capturing data and exporting it will invalidate the results, i.e they will be incorrect.

Should you realize that such an error has been made, you can correct it by reinstating the channel definition with which the results were originally captured. Then, as long as the module has not been rearmed, the captured results may be exported in their correct form.

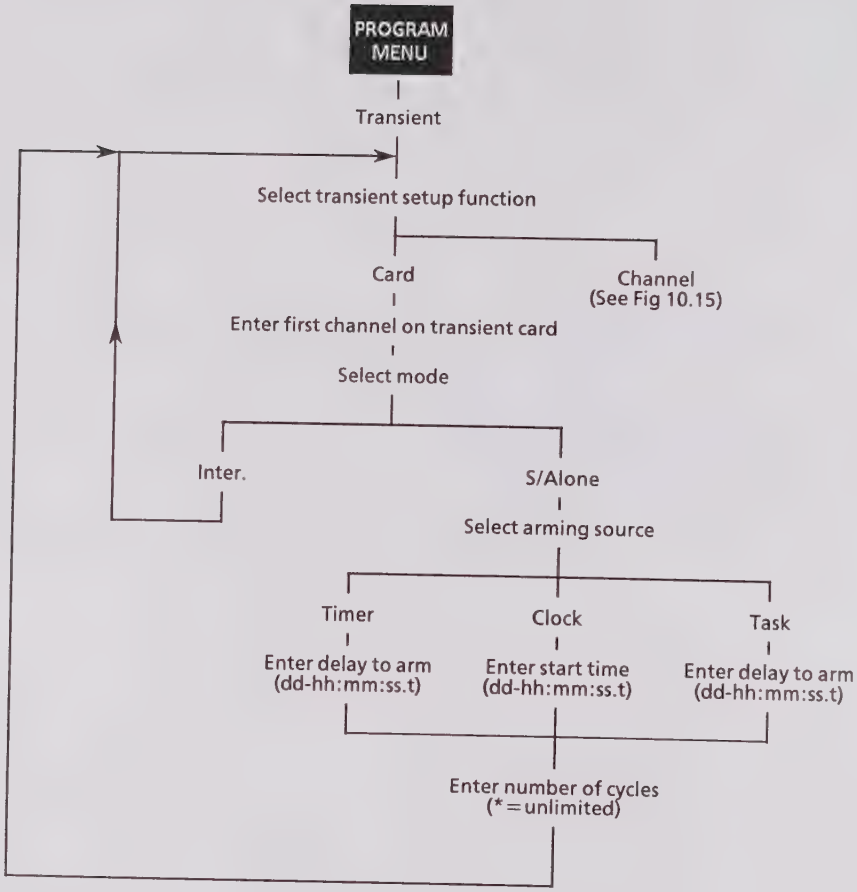

Fig 10.14 *The PROGRAM menu for a transient card.*

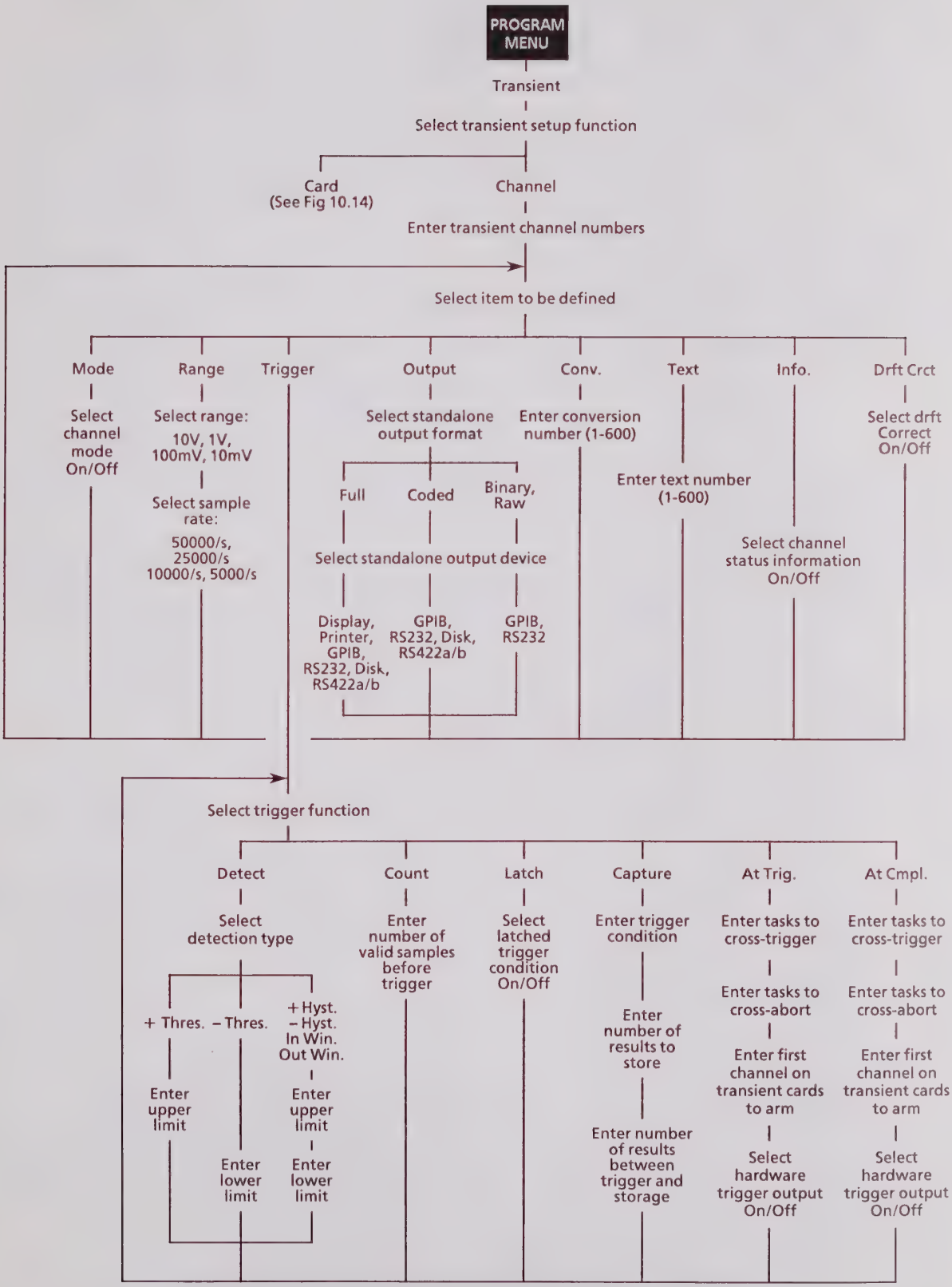

Fig 10.15 *The PROGRAM menu for a transient channel.*

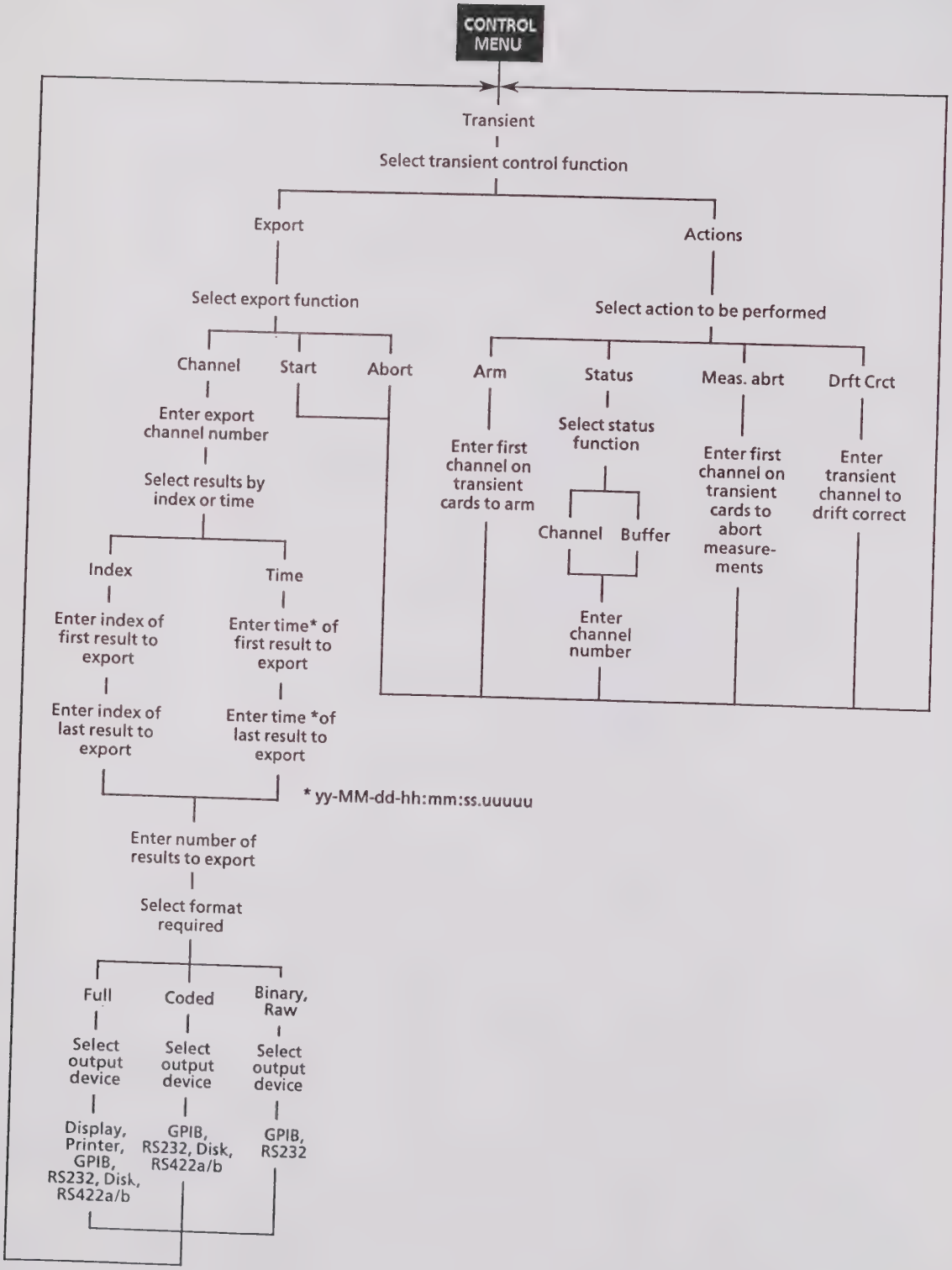

Fig 10.16 *The CONTROL menu for interactive transient capture.*

Appendix A
SI3535 Specification

All limits of error are quoted for 1 year at 20 ±3°C, 1 hour warm-up time.
Temperature coefficients apply over the full operating range.
Analog specifications are dependent on type of analog scanner.

A-D Converter

Integrating pulse-width conversion technique

Input impedance: 100Vdc/20Vac: >1MΩ
other ranges: >1GΩ <100pF
Input Current: <200pA

Integration time	50Hz 60Hz	0.625ms 0.521ms	5ms 4.17ms	20ms 16.67ms	80ms 66.67ms
Scale length:		1000	10000	100 000	100 000
Scan rate, high speed solid-state:		500/s	100/s	40/s	10/s
high voltage solid-state:		250/s	90/s	35/s	10/s
reed relay:		140/s	80/s	35/s	10/s
System throughput *:		500/s	100/s	40/s	10/s

* 25 thermocouples, continuously scanned with alarm limits, coded format, output to disk, GPIB or memory, high speed solid-state scanner

Interference Rejection

Integration time		20ms	80ms
Normal mode:	50/60Hz ±2%:	>60dB	>70dB
Common mode:*	dc: reed relay, high voltage solid-state:	>140dB	>140dB
	high speed solid-state:	>130dB	>130dB
	50/60Hz ±2%:		
	reed relay, high voltage solid-state:	>130dB	>140dB
	solid-state:	>120dB	>120dB

* Assumes Guard connected to source and 1kΩ imbalance

DC Voltage

Int. Time: 0.625ms Range	5ms Sensitivity	20/80ms Limits of Error	Temperature Coeff.
100V* 100mV	10mV	1mV <±[0.05% + 2 digits]	<±0.003%/°C
10V 10mV	1mV	100µV <±[0.005% + 2 digits + 3µV]	<±[0.001% + 0.1µV]/°C
1V 1mV	100µV	10µV <±[0.005% + 2 digits + 3µV]	<±[0.001% + 0.1µV]/°C
100mV 10µV	10µV	1µV <±[0.005% + 2 digits + 3µV]	<±[0.001% + 0.1µV]/°C
10mV 10µV	1µV	1µV <±[0.005% + 2 digits + 3µV]	<±[0.001% + 0.1µV]/°C

* not permissible with high speed solid-state scanner
(For 0.625ms and 5ms integration times the limits of error are 0.005% + 2 digits + 20µV for 10mV, 100mV, 1V, 10V ranges. 0.05% + 2 digits for 100V range.)

DC Current

Assumes 100Ω shunt (connector 35303B)
20/80ms integration time

Range	Sensitivity	Limits of Error** (at <40mA)	Temperature Coeff.
100mA	1µA	<±[0.02% + 2 digits + 60nA]	<±[0.0015% + 1nA]/°C
10mA	100nA	<±[0.02% + 2 digits + 60nA]	<±[0.0015% + 1nA]/°C
1mA	10nA	<±[0.02% + 2 digits + 60nA]	<±[0.0015% + 1nA]/°C
100µA	10nA*	<±[0.02% + 2 digits + 60nA]	<±[0.0015% + 1nA]/°C

* 1nA digit is present to preserve accuracy during internal processing only; limits of error calculations are based on 10nA digits, ie., <±[0.02% + 20nA + 60nA]
** Limits of Error do not include analog input selector thermal errors. Total system error is calculated by adding 2µV divided by shunt resistance

AC Voltage

True rms of ac + dc
Nominal speed: 5/s

Range	Sensitivity	Limits of Error** 40Hz<=f<=10kHz	Limits of Error** 20Hz<=f<=20kHz	Temp Coeff.
19V*	1mV	<±[0.5% + 0.1V]	<±[2% + 0.1V]	<±0.015%/°C
2V	100µV	<±[0.5% + 10mV]	<±[2% + 10mV]	<±0.015%/°C
200mV	10µV	<±[0.5% + 1mV]	<±[2% + 1mV]	<±0.015%/°C
30mV	1µV	<±[0.5% + 0.15mV]	<±[2% + 0.15mV]	<±0.015%/°C

* not permissible with high speed solid state scanner
** crest factor <4:1, reading >10% range

AC Current

True rms
Nominal speed: 5/s

Range	Sensitivity	Limits of Error** 40Hz<=f<=10kHz	Limits of Error** 20Hz<=f<=20kHz	Temp Coeff.
190mA*	10µA	<±[0.5% + 1mA]	<±[2% + 1mA]	<0.015%/°C
20mA	1µA	<±[0.5% + 100µA]	<±[2% + 100µA]	<0.015%/°C
2mA	100nA	<±[0.5% + 10µA]	<±[2% + 10µA]	<0.015%/°C
300µA	10nA	<±[0.5% + 1.5µA]	<±[2% + 1.5µA]	<0.015%/°C

* not permissible with high speed solid state scanner
** crest factor <4:1, reading >10% range

Thermocouple Measurement

Linearization to IEC584 (BS 4937)
80ms integration time
1 year Accuracy

Type °C	Range °C	Total System Accuracy (°C)* Connector Type: Isothermal	Standard
E	−200 to +1000		
	−100 to −60	0.55	1.09
	−60 to +50	0.49	0.97
	50 to 200	0.40	0.79
	200 to 700	0.35	0.69
	700 to 1000	0.39	0.72
J	−210 to 1200		
	−80 to 0	0.50	0.98
	0 to 480	0.45	0.86
	480 to 650	0.43	0.80
	650 to 890	0.40	0.74
	890 to 1200	0.45	0.82
K	−210 to 1372		
	−30 to +40	0.50	0.93
	40 to 110	0.46	0.86
	110 to 640	0.48	0.89
	640 to 1040	0.54	0.96
	1040 to 1250	0.59	1.05
	1250 to 1372	0.63	1.10
T	−210 to 400		
	−210 to −30	1.22	2.35
	−30 to 30	0.50	0.95
	30 to 95	0.45	0.84
	95 to 150	0.40	0.75
	150 to 400	0.37	0.70

3535D, F and G Specification

Type °C	Range °C	Total System Accuracy (°C)* Connector Type: Isothermal	Standard
R	0 to 1767		
	0 to 75	1.30	1.74
	75 to 200	1.00	1.34
	200 to 500	0.82	1.09
	500 to 1000	0.69	0.91
	1000 to 1500	0.60	0.78
	1500 to 1767	0.66	0.85
S	0 to 1767		
	0 to 75	1.27	1.70
	75 to 200	1.02	1.36
	200 to 500	0.85	1.13
	500 to 1000	0.75	0.99
	1000 to 1500	0.67	0.88
	1500 to 1767	0.76	0.98
B	80 to 1820		
	250 to 520	2.00	2.04
	520 to 600	1.00	1.00
	600 to 800	0.88	0.88
	800 to 1820	0.70	0.71
N	−250 to +1300		
	−100 to −50	0.68	1.19
	−50 to −20	0.59	1.03
	−20 to +250	0.57	0.98
	250 to 1030	0.45	0.76
	1030 to 1300	0.49	0.78

* Total System Accuracy at 20°C ± 3°C includes ADC, scanner, conformity, and reference junction errors using the 35353C Isothermal or 35303C Standard connectors' ambient measurement. Specifications for the full operating and measurement ranges are available in the 3535 User Guide.

Platinum RTD Measurement

Linearization to IEC 751*
Requires 35351D Transducer Energization Module.
80ms integration

Range °C	Total System Accuracy**
−200 to 115	0.10
115 to 450	0.20
450 to 600	0.25

* Other RTD types can be dealt with by configuring as a resistance and applying user-defined conversions and energization current.
** Total System Accuracy °C (1 year) includes all ADC, scanner, energization and conformity errors. Probe calibration can improve accuracy, as 24 hour repeatability is 0.03°C from −200 to +300°C.

Resistance Measurement

Requires transducer energization module 35351D

4-terminal, 1mA energization

Integration time: 50Hz: / 60Hz:		0.625ms 0.521ms	5ms 4.17ms	20/80ms 16.67/66.67ms
Range	Full scale	Sensitivity		
10kΩ	13.7kΩ	10Ω	1Ω	100mΩ
1kΩ	1.7kΩ	1Ω	100mΩ	10mΩ
100Ω	200Ω	100mΩ	10mΩ	1mΩ
10Ω	25Ω	10mΩ	1mΩ	1mΩ*

Limits of Error**
At 20/80ms integration time: <±[0.015% + 2 digits + 6mΩ]
At 0.625/5ms integration time: <±[0.015% + 2 digits + 20mΩ]

* 100μΩ digit is present to preserve accuracy during internal processing only; limits of error calculations are based on 1mΩ digits, ie., <±[0.015% + 2mΩ + 6mΩ]
** Errors may exceed those quoted if measurements of high resistance are made in conditions of high humidity, (eg., >60%RH)

4-terminal, 100μA energization

Integration time: 50Hz: / 60Hz:		0.625ms 0.521ms	5ms 4.17ms	20/80ms 16.67/66.67ms
Range	Full scale	Sensitivity		
100kΩ	137kΩ	100Ω	10Ω	1Ω
10kΩ	17kΩ	10Ω	1Ω	100mΩ
1kΩ	2kΩ	1Ω	100mΩ	10mΩ
100Ω	250Ω	100mΩ	10mΩ	10mΩ*

Limits of Error**
At 20/80ms integration time: <±[0.015% + 2 digits + 60mΩ]
At 0.625/5ms integration time: <±[0.015% + 2 digits + 200mΩ]
On 100kΩ range (all integration times): <±[0.03% + 2 digits]

* 1mΩ digit is present to preserve accuracy during internal processing only; limits of error calculations are based on 10mΩ digits, ie., <±[0.015% + 20mΩ + 60mΩ]
** Errors may exceed those quoted if measurements of high resistance are made in conditions of high humidity, (eg., >60%RH)

Strain Measurement

Requires transducer energization module 35351D
Full, half, quarter, and 3-wire bridge configurations measured

Bridge Type	Sensitivity	Repeatability 24hrs	Limit of Error
Full:-2V or 10V*	0.2με	4με	<30με
Half**	0.1με	2με	<15με
Quarter**	0.1με	2με	<15με

* Figures are for 1200 gages (2V) and 3500 gages (10V)
** Figures are for 1200 gage, 8.33mA energization, gage factor 2, Bridge Imbalance: <10000με

Transducer Energization Module 35351D

Voltage, for full-bridge strain: 10V (≥350Ω gage); 2V (≥120Ω gage)
Temperature coefficient 10V: 100ppm/°C
2V: 25ppm/°C
Current: Twin currents for resistance, PRT, ½- and ¼-bridge strain
Values: 100μA, 1mA, 8.33mA*
* A fourth current, up to 10mA, may be defined by a resistor fitted by the user.

Slave Expansion Unit 3535E

One or two slave units may be connected to 3535D, F or G:
Each slave will house up to 10 analog input scanners. Performance when slaves are connected is the same as that given above, except:

Common mode rejection of dc and ac: reduced by 10dB per slave
Channel crosstalk at dc: reduced by 10dB per slave
Accuracy: AC voltage:
20V range, 10kHz to 20kHz: reduced by 0.5% rog per slave
Resistance, 100kΩ range: reduced by 0.02% rog per slave
(These figures apply with Schlumberger cables less than 1m long)

Analog Input Modules

Scanner type	35351G/H High Voltage Solid-state	35301J High Speed Solid-state	35301K/L Reed Relay
Channels: 3 poles:	20	20	20
6 poles:	10	10	10
Isolation, channel to ground:	>10GΩ<1000pF	>1GΩ<1000pF	>10GΩ<300pF
Input Capacitance:	<1000pF	<750pF	<120pF
Crosstalk immunity at dc:	>120dB	>120dB	>120dB
at 10kHz:	>40dB	>80dB	>80dB
Switch life: (<10V, <10mA)	$>10^{10}$	unlimited	$>10^{8}$
Leakage current:	<1nA	<10nA	0nA
Maximum scan rate:	250/s	500/s	140/s
Maximum measured voltage:	±105	±13.7	±105
Maximum voltage any input to ground:	±150	±14	±200

35353C isothermal universal analog connector is included with 35351H and 35301K.
35303A standard universal analog connector is included with 35351G, 35301J and 35301L.

Transient Capture Module 35351F

Architecture: 4 channels per module; each channel pair has a floating common low input – maximum 4 modules per 3535 mainframe
Analog to Digital Converters: separate ADC per channel
16 bit output resolution (15 bits + sign); 4 fixed ranges
Data storage within module: 1 million results, divided between channels as required
Sample rates: 5/50/500/5000/10000/25000/50000 samples per second/channel
Bandwidth: dc to 20KHz, passband ripple ±0.1dB (1.12%)
Anti-alias filter response: −60dB at 30KHz

Accuracy at DC

Range	Resolution	Limits of Error*	Temp. coeff.**	RMS Noise***
10V	1mV	0.026% + 1	0.002% + 100μV	1mV
1V	100μV	0.026% + 2	0.002% + 10μV	100μV
100mV	10μV	0.026% + 2	0.002% + 2.5μV	30μV
10mV	1μV	0.046% + 9	0.004% + 1μV	20μV

* 1 year, 20 ± 3°C, <% reading + digits)
** <± (% reading + offset)/°C
*** Short cct input, <± Vrms

3535D, F and G Specification

Hardware triggers:	one input and one output per card (TTL levels)
Pre/post trigger:	−100% pre-trigger to +1600% post-trigger (minimum: one channel into 1 million memory)
Trigger modes:	above or below threshold (with or without hysteresis); inside or outside window; complex trigger combinations on multiple channels within one module – eg (channel 1 >0.1V) AND (channel 2 <3.5V)
Overload protection Hi/Lo:	±100V peak (±30V on trigger input)
Isolation, any input to ground:	±200V peak
Common Mode Rejection Ratio: dc	>130dB
: 50/60Hz	>60dB
Input current, Hi to Lo:	<2.2nA
Input resistance, Hi to Lo:	1Mohm ± 10%
Input signal crosstalk, dc & 1KHz:	>100dB
Skew timing error:	<200ns within card, 1 sample between cards using external trigger
Input connections:	2 connectors (2 input channels each) are supplied spares may be ordered as 351505030

Analog Output Module 35301E

Channels, voltage or current:	5, isolated
Isolation, per channel:	200V
Resolution:	12 bit
Settling time to 1 bit:	<300ms
Noise:	<0.1% fs (rms)

Output	Range	Resolution	Drive Limit	Error
Voltage	0 to + 10V	2.44mV	20mA	<[0.1% + 5mV]
Current	4 to 20mA	4.88µA	10V	<[0.1% + 10µA]

Temp Coefficient: <[0.01% + 500µV]/°C or <[0.01% + 1µA]/°C

Counter-Timer Module 35302C

Each channel has available both signal and gate inputs. Each input may be separately set to differential or TTL; either can be active Hi or active Lo.
The latest result is read when a channel is scanned.

Number of channels:		5
Differential sensitivity:		600mV
Operating window:		+7V to −7V about Ground
Overload protection,	signal:	25V max.
	common mode:	25V max.
Speed of measurement update:		1/s
Limits of Error, for 1 year, 5° to 40°C:		±0.005% rdg
Form of result:		5 significant digits 3 digits + exponent when >3 × 10^7

Frequency

Maximum input:		400kHz
Gate time,	internal:	0.1, 1, 10 or 100s
	external:	600s max.

Period

Maximum frequency:		400kHz
Number of periods measured:		1, 10, 100, 1000 or 10 000
Total time for periods selected:	minimum:	500µs
	maximum:	60 mins
Resolution:		1µs

Interval
Time between positive and negative transitions, or the inverse.

Interval length:	minimum:	500µs
	maximum:	60 mins
Resolution:		1µs
Minimum time between intervals:		20ms

Totalize
Counts pulses in one of two ways:
1. A running total read on each scan;
2. A total accumulated during a gate input, reset to zero for each new gate.

Maximum input frequency:	400kHz
Minimum pulse width:	1.25µs
Maximum count:	32 bits (>4 × 10^9)

Event-Status Module 35302D

Channels:	20, opto-isolated
Isolation, each channel:	200V
Maximum input:	80V
Input current:	0.7mA min, 7mA max
Energization:	individually any input may be energized from the internal 5V supply, or from one of two external voltages
Internal energization supply:	+5V nominal, 40mA max
External energization supply:	4V to 12V, or 12V to 80V

Events

Pulse input, minimum width:	2ms
Maximum allowable transitions per instrument*.	2000/s
Events selectable:	Lo to Hi, or Hi to Lo, or both
Event totalizing:	65535 max
Event timing:	±2ms

(*summed over all event-status inputs fitted)

Status

Level recognised:		Hi or Lo
Channel grouping:		single or grouped bits
Module interfacing:		1-2-4-8 bcd
Reading rate,	single bit:	500 bit/s
	as groups:	1000 bit/s

Connector 35303A is included with 35302D

Digital Input-Output Module 35302B

Input channels:	20 lines
Output channels:	20 lines
Inputs and outputs are floating with one common return	
Isolation:	100V

Inputs

Maximum input:		+40V
Level recognised: CMOS compatible:		Logic 0 >3.5V Logic 1 <1.5V
Channel grouping:		single or grouped bits
Reading rate,	single bit:	500 bit/s
	as groups:	1000 bit/s

Outputs
All 20 outputs can operate in one of three ways:

1. Using internal + 5V supply (common 0V):	
Logic 0, sourcing 0mA:	>4V
Logic 1, sinking 16mA from external source:	<0.4V
2. Using external supply (common 0V):	
Maximum supply:	+25V
Logic 0, sourcing 0mA:	supply voltage
Logic 1, sinking 16mA from external source.	<0.4V
3. As On/Off switches (common 0V):	
Maximum rating, on:	150mA
Maximum rating, off:	+40V

Processing Language

Up to 500 lines of BASIC processing are available

Functions and Operators
+ − * / ** = < > <> <= >=
AND OR SIN COS ATAN SQR. EXP LN ABS
Numeric and string constants
Simple and indexed variables
8 independent Timers

Control statements:	IF THEN ELSE ENDIF FOR TO NEXT STEP GOTO SET PRINT WRITE
Task cross-triggering:	TRIGGER and ABORT

Arrays

Channel results:	C1 → C600, C(I), SC(I)
Channel Alarm Levels:	High alarms H1 → H600, H(I), SH(I) Low alarms L1 → L600, L(I), SL(I)

Communication Interfaces

The three types of interface may be used as output-only, to send results to an external printer or recorder, or for connection to a computer, allowing full control of 3535.

Standard Serial Interface

Included in the Controller Module supplied with each 3535

Electrical standard:	RS232C Type D
Connector:	25 way, Type D
Data rate, switch selectable:	75/1200, 300, 1200, 2400, 4800, 9600, 19200 baud
Transmitted code, switch selectable:	7/8 bit, odd, even, no parity
Received code, switch selectable:	7/8 bit, odd, even, no parity
Maximum cable length:	15m (50ft)

Serial Interface Module 35304B

This optional interface is primarily intended for high-speed communication with a computer.

Number of ports:	2
Port A is output only. Port B is output only or BS4505 protocol.	
Electrical standard:	RS422 or RS232C Type D
Connector:	25 way, Type D
Data rate, switch selectable:	300 to 155.6k baud
Transmitted code:	ASCII 7-bit + selectable parity
Received code:	ASCII 7-bit + selectable parity
Maximum cable length:	1.2km (4000ft)

GPIB Interface Module 35304A

This optional interface enables 3535 to be connected on a general instrument bus.

Electrical standard:	IEEE 488
Connector:	24 way, Amphenol
Parallel Poll sub-set:	PP1

Printer (3535D only)

Paper width:	110mm (4.33in)
Print speed:	2 lines/s
Characters per line:	80
Roll capacity:	approx 20 000 lines

Disk Unit (3535 D and G)

Disk type:	3.5 inch, double sided
Disk format:	MS-DOS* or HP-LIF
Disk capacity:	
Channel records per disk, full format:	>15 000
compact format:	>30 000
encoded format:	>60 000
Channel record speed, encoded format:	500/s
Program storage:	up to 4 total instrument set-ups (3 for HP-LIF format)

*Free PC utility converts to Lotus DIF format

Environment

Temperature, Operating:		3535F:	0 to 50°C, 50% RH
		3535D, G:	5 to 40°C, 80% RH
Storage:			−20 to 60°C
Storage assumes disk not present			
Vibration:	DEF STD 66/31 Issue 01:	Operating:	5-16Hz ±0.1mm 16-30Hz 0.98mS^{-2}
		Storage:	5-13Hz ±1.5mm 13-150Hz 9.8mS^{-2}
	MIL T 28800 D	Operating:	5-55Hz ±0.165mm

Power Supply

AC, or external battery, or both may be connected.

AC:	90 to 132V/180 to 264V, 45 to 63Hz, 300VA
Battery:	12-32V
Memory and clock battery, NiCd rechargeable:	life >20 days

Power fail: external dc takes over if ac fails. Internal battery maintains memory and clock if external battery not present; automatic restart when power restored.

Dimensions

	3535F	3535D&G
Length:	510mm (20ins)	610mm (24ins)
Width:	432mm (17ins)	432mm (17ins)
Height (including 20mm feet):	241mm (9.5ins)	241mm (9.5ins)
Weight, all modules fitted:	26kg (57lbs)	28kg (62lbs)

Accessories

The following are supplied with 3535:

Fuses, 4 paper rolls (with 3535D only), 2 rack mount brackets, module extractor, User Manual, Reference Manual and 2 floppy disks.

WARNING: Should the instrument be subjected to a strong continuous magnetic field, measurement accuracy may be affected.

Appendix B
Typical Throughputs

Section *Page*

1 Introduction B.3

2 Transient Export Throughputs B.6

Table

B.1 O/P to GPIB: Type B Thermocouple; No Alarms; Blocking Off B.4
B.2 O/P to GPIB: Type B Thermocouple; Alarms Active; Blocking Off B.4
B.3 O/P to GPIB: Type B Thermocouple; No Alarms; Blocking On (8K) B.4
B.4 O/P to GPIB: Type B Thermocouple; Alarms Active; Blocking On (8K) ... B.4
B.5 O/P to GPIB: Strain Gage; No Alarms; Blocking Off; 40 readings/sec B.5
B.6 O/P to GPIB: Strain Gage; Alarms Active; Blocking Off; 100 readings/sec B.5
B.7 O/P to Disk: Type B Thermocouple; No Alarms; Blocking Off B.5
B.8 O/P to Disk: Type B Thermocouple; Alarms Active; Blocking Off B.5
B.9 Transient Export Throughputs B.6

1 INTRODUCTION

This appendix gives typical figures for the throughput of data for the SI 3535 Data Logger. ("Throughput" means channel data that have passed completely through the logger, from sensor to output device.)

Throughput rates depend on:

- the channel configuration,
- the type of linearization,
- the task activity, and
- the speed of the output device.

The throughput rates achievable are presented in tabular form, under eight headings. Each table represents a particular measurement setup, as follows:

Table	**Measurement Setup**			
	Sensor	*Alarm Detect*	*Data Blocking*	*Output Device*
B1	Type B Therm'cpl	Off	Off	GPIB
B2	Type B Therm'cpl	ON	Off	GPIB
B3	Type B Therm'cpl	Off	ON (8K block)	GPIB
B4	Type B Therm'cpl	ON	ON (8K block)	GPIB
B5	Strain Gage	Off	Off	GPIB
B6	Strain Gage	ON	Off	GPIB
B7	Type B Therm'cpl	Off	Off	Disk
B8	Type B Therm'cpl	ON	Off	Disk

Note that, in the figures given, throughput rates increase with the number of channels scanned. Any further increase in the number of channels scanned produces no further increases in the throughput rate, which generally remains at the highest figure. These rates were obtained with continuous scanning: higher rates can be obtained by repeatedly requesting a single scan, eg. channels 1-20, 1-20, 1-20 in the Task setup.

A reading rate of 500/s was used for all the type B thermocouple inputs, whilst reading rates of 40/s and 100/s were used for the strain gage throughputs of Tables B5 and B6.

The remote commands with which the logger was set up for obtaining the throughput rates are listed below. The rates were calculated by tracing 3000 measurements.

Throughput Rate Setup:

```
BU 500                                          500 result buffer.
CH 121-140 SE 375                               Type B thermocouples.
DR OF                                           Drift correct off.
TA 1 OP ME TR TI DE 0.5 CO * RE IN IN 0.1       Task setup.
TA 1 CH 121 AT 3 TA 1 PR OFF LO EV MA NO        Task setup.
TA 1 FO AS TO GP                                Task setup.
```

B.1 O/P to GPIB: Type B Thermocouple-No Alarms-Blocking Off

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	63	326	374	385	389
Compact	63	322	430	450	455
Coded	63	337	495	510	515
Binary	63	319	403	423	428
Full tagged	63	315	355	382	388
Binary tagged	63	324	397	417	424

B.2 O/P to GPIB: Type B Thermocouple-Alarms Active-Blocking Off

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	63	322	359	374	379
Compact	63	315	415	436	444
Coded	63	324	454	490	507
Binary	63	310	381	398	405
Full tagged	63	316	347	360	365
Binary tagged	63	320	374	392	397

B.3 O/P to GPIB: Type B Thermocouple-No Alarms-Blocking On (8K)

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	63	305	418	447	460
Compact	63	315	446	474	483
Coded	63	320	462	490	505
Binary	63	317	464	495	509
Full tagged	63	314	419	437	444
Binary tagged	63	306	457	487	508

B.4 O/P to GPIB: Type B Thermocouple-Alarms Active-Blocking On (8K)

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	63	313	406	430	434
Compact	63	313	431	463	478
Coded	63	322	453	492	505
Binary	63	312	452	491	510
Full tagged	63	318	393	409	419
Binary tagged	63	323	450	486	503

B.5 O/P to GPIB: Strain Gage-No Alarms-Blocking Off-40 readings/sec

Format	Throughput (chans/sec)					
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels	Scan=100 channels
Full	16	21	22	22	22	23
Compact	16	21	22	22	22	23
Coded	16	21	22	22	22	23
Binary	16	21	22	22	22	23
Full tagged	16	21	22	22	22	23
Binary tagged	16	21	22	22	22	23

B.6 O/P to GPIB: Strain Gage-Alarms Active-Blocking Off-100 readings/sec

Format	Throughput (chans/sec)					
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels	Scan=100 channels
Full	30	56	63	67	69	70
Compact	30	56	63	67	69	70
Coded	30	56	63	67	69	70
Binary	30	56	63	67	69	70
Full tagged	30	56	63	67	69	70
Binary tagged	30	56	63	67	69	70

B.7 O/P to Disk: Type B Thermocouple-No Alarms-Blocking Off

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	51	148	183	224	259
Compact	56	200	288	386	402
Coded	59	251	401	450	496
Full tagged	51	143	183	245	259

B.8 O/P to Disk: Type B Thermocouple-Alarms Active-Blocking Off

Format	Throughput (chans/sec)				
	Scan=1 channel	Scan=5 channels	Scan=10 channels	Scan=25 channels	Scan=50 channels
Full	51	141	186	229	260
Compact	56	199	303	354	358
Coded	60	244	415	450	499
Full tagged	51	141	190	245	259

2 TRANSIENT EXPORT THROUGHPUTS

Shown in Table B.9 are the typical throughputs for transient export data, in *results* per second. These figures were derived from the time taken to capture and export 10,000 results, in Stand Alone mode; except in the case of raw format data, where the figures were derived from the fact that 1,000,000 results were captured and exported in 24 seconds.

The output devices were:

RS232	VT220 Terminal (19200Baud).
Disk	SI 3535D and G internal floppy disk.
GPIB	Talk Only to dummy device (NDAC=!DAV). This "device" receives bytes as fast as the SI 3535 can send them.

B.9 Transient Export Throughputs

Format	Throughput (results/sec)		
	GPIB	Disk	RS232
ASCII	526	238	86
Coded	588	322	153
Binary	588	xxx	181
Raw*	41666	xxx	833

*Not supported by 3470 Systems.

The throughputs achieved for specific systems depend on the total system configuration.

Appendix C Thermocouple Measurement Accuracy

Section *Page*

1 **Thermocouple Measurement Accuracy** C.3

Table

C.1 E Type Thermocouple -200 to 1000 ..... C.3
C.2 J Type Thermocouple -210 to 1200 ..... C.3
C.3 K Type Thermocouple -210 to 1372 ..... C.3
C.4 T Type Thermocouple -210 to 400 ..... C.4
C.5 R Type Thermocouple 0 to 1767 ..... C.4
C.6 S Type Thermocouple 0 to 1767 ..... C.4
C.7 B Type Thermocouple 80 to 1820 ..... C.5
C.8 N Type Thermocouple -250 to 1300 ..... C.5

1 THERMOCOUPLE MEASUREMENT ACCURACY

Linearisation to IEC584 (BS 4937)
80ms integration time
1 year accuracy

Total System Accuracy includes ADC, scanner, conformity and reference junction errors using the 35353C Isothermal or 35303C Standard connectors' ambient measurement. Specifications for the full operating and measurement ranges are as follows :-

C.1 E Type Thermocouple -200 to 1000

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
-200	-100	0.95	1.25	1.60	1.91	2.42	2.99
-100	-60	0.55	0.71	0.89	1.09	1.37	1.68
-60	50	0.49	0.63	0.79	0.97	1.21	1.47
50	200	0.40	0.50	0.61	0.79	0.97	1.16
200	700	0.35	0.51	0.68	0.69	0.88	1.12
700	1000	0.39	0.59	0.82	0.72	0.99	1.29

C.2 J Type Thermocouple -210 to 1200

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
-210	-80	1.09	1.44	1.87	2.16	2.72	3.32
-80	0	0.50	0.65	0.80	0.98	1.21	1.46
0	480	0.45	0.58	0.73	0.86	1.06	1.26
480	650	0.43	0.58	0.73	0.80	1.03	1.25
650	890	0.40	0.58	0.81	0.74	0.98	1.27
890	1200	0.45	0.68	0.98	0.82	1.12	1.49

C.3 K Type Thermocouple -210 to 1372

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
-210	-30	1.30	1.71	2.20	2.48	3.12	3.85
-30	40	0.50	0.64	0.75	0.93	1.15	1.35
40	110	0.46	0.57	0.72	0.86	1.05	1.28
110	640	0.48	0.65	0.87	0.89	1.10	1.41
640	1040	0.54	0.78	1.10	0.96	1.29	1.67
1040	1250	0.59	0.88	1.25	1.05	1.42	1.89
1250	1372	0.63	0.94	1.35	1.10	1.51	2.02

C.4 T Type Thermocouple -210 to 400

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
-210	-30	1.22	1.61	2.10	2.35	2.98	3.74
-30	30	0.50	0.64	0.82	0.95	1.19	1.48
30	95	0.45	0.56	0.71	0.84	1.05	1.29
95	150	0.40	0.50	0.63	0.75	0.93	1.14
150	400	0.37	0.48	0.61	0.70	0.88	1.08

C.5 R Type Thermocouple 0 to 1767

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
0	75	1.30	1.64	2.07	1.74	2.20	2.75
75	200	1.00	1.26	1.54	1.34	1.69	2.06
200	500	0.82	1.04	1.28	1.09	1.38	1.69
500	1000	0.69	0.90	1.13	0.91	1.18	1.47
1000	1500	0.60	0.86	1.21	0.78	1.07	1.47
1500	1767	0.66	0.99	1.42	0.85	1.22	1.71

C.6 S Type Thermocouple 0 to 1767

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
0	75	1.27	1.60	2.05	1.70	2.15	2.71
75	200	1.02	1.28	1.59	1.36	1.72	2.11
200	500	0.85	1.08	1.34	1.13	1.43	1.77
500	1000	0.75	0.98	1.24	0.99	1.28	1.61
1000	1500	0.67	0.97	1.36	0.88	1.22	1.66
1500	1767	0.76	1.12	1.60	0.98	1.40	1.94

C.7 B Type Thermocouple 80 to 1820

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
80	250	7.37	9.24	11.55	7.39	9.39	11.86
250	520	2.00	2.55	3.19	2.04	2.59	3.28
520	600	1.00	1.27	1.61	1.00	1.29	1.66
600	800	0.88	1.13	1.44	0.88	1.15	1.48
800	1820	0.70	0.92	1.19	0.71	0.93	1.22

C.8 N Type Thermocouple -250 to 1300

Measurement Range		Total System Accuracy (°C)					
		35353C ISOTHERMAL Operating Temp. Range °C			35303C STANDARD Operating Temp. Range °C		
		20±3	15-35	0-50	20±3	15-35	0-50
-250	-100	4.29	5.58	7.17	7.70	9.72	12.05
-100	-50	0.68	0.86	1.09	1.19	1.48	1.81
-50	-20	0.59	0.74	0.93	1.03	1.27	1.55
-20	250	0.57	0.70	0.87	0.98	1.20	1.46
250	1030	0.45	0.64	0.87	0.76	0.98	1.27
1030	1300	0.49	0.73	1.01	0.78	1.09	1.44

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